Feasibility Report

Housatonic River Basin Urban Study

September 1982

US Army Corps of Engineers
New England Division

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HOUSATONIC URBAN STUDY

MAIN REPORT

Housatonic Urban Study

Summary

The Housatonic Urban Study is an investigation of the water resources problems in the Housatonic Watershed, located in Massachusetts and Connecticut. The study area includes the entire Housatonic Basin and all or part of 19 communities in Massachusetts and 44 communities in Connecticut. No studies were undertaken for the portion of 11 New York communities located along the western fringe of the basin, where no significant water resources problems are known to exist at this time. This includes five towns along Green River in Columbia County and six towns along the Tenmile River, principally in Dutchess County.

The study was initiated by the New England Division in October 1977 as the result of three congressional resolutions. The Reconnaissance Report, approved by the Corps, Office Chief of Engineers (OCE) in September 1979, identified two major problem areas, flood control and water supply. The Stage 2 study of these problems was authorized in October 1979 and recently completed.

Stage 2 documentation is contained in four appendices, the Problem Identification Appendix, the Plan Formulation Appendix, the Technical Appendix and the Comments Appendix. This report highlights the detailed information contained in those appendices.

Soliciting the views of State and local officials, interested agencies and individuals on the area's water resources problems and needs was the first major task performed. A general mailing presented the study's focus and requested local input. State officials regarded water supply and flood management as the primary concerns. Local responses were consistent with State views.

WATER SUPPY

Presently 146 water systems in the study area serve water to 975,000 people. There are 131 systems in Connecticut serving an average of 150 million gallons of water per day, and 15 systems in Massachusetts serving 18 million gallons per day.

Utilizing demographic information and data collected from existing water supplier records, future water supply demands were estimated and the systems with the potential to experience future deficits were identified. The water demand projections for Connecticut indicate that five water companies will have an average day demand by the year 2000 that exceeds their safe yield. The total deficit is estimated to be three million gallons per day. By the year 2030, 13 water companies will have a total deficit of 19 million gallons per day. Most of the deficit (14 mgd) is concentrated in the southwestern portion of Connecticut. It should be

noted that the availability of potential sources is much higher in the northern section of Connecticut while populations are heaviest in the southern portion.

Water demand projections for the water utilities in Massachusetts indicate that by the year 2000, four will have average day demands in excess of their safe yield. The total deficit will be only 1.02 mgd. But by the year 2030 a total of six water companies will have a deficit that totals almost 7 mgd.

A major problem is that many towns have not been able to locate and develop near potential sources. In some areas new well sites are non-existent, in others aquifers are either developed to their maximum potential or have been lost due to residential or commercial development. Some aquifers are being abandoned because of contamination. Communities utilizing surface water supplies are also beginning to experience difficulty in locating additional supplies.

Various measures to meet projected future demands were examined both on a regional and a community by community basis. Potential measures examined included development of groundwater sources, development of surface water sources, lake/river withdrawals or diversions, desalination and water conservation.

Large regional systems utilizing new supply sources, such as; the Shepaug River, the West Aspetuck River and Candlewood Lake, were evaluated but none passed initial screenings of cost, social and environmental impacts as well as public acceptability.

Solutions were therefore evaluated on a community-by-community basis and are considered more cost effective and more responsive to the needs of local officials and within their capability to implement.

It is recognized that decisions on future water supply development are matters of local concern and action. The water supply information developed as part of this study should assist local planning for future needs.

FLOOD CONTROL

The Housatonic River Basin is vulnerable to destructive floods during any season of the year as a result of ice, heavy rainfall, melting snow or combinations thereof. Within the past 60 years the basin has experienced numerous flood events, the most significant occurring in 1927, 1936, 1938, 1948-49, 1955, 1969, 1973 and 1977. In the August 1955 flood, the flood of record in some parts of the basin, 47 lives were lost and damages were estimated at $245 million. Since this destructive event seven Corps reservoirs and nine Corps local protection projects have been built.

Even though much flood control work has been done, many areas are still vulnerable to flood damages. Detailed investigations determined that 14 communities (3 in Massachusetts and 11 in Connecticut) warranted further flood control evaluation. A detailed investigation of the 100-year flood plain showed that nearly 4000 structures are subject to damage. Discussions of flood problems within the 14 communities are contained on pages 109-116 of the Problem Identification Appendix. Identification of flood prone properties within each basin community is contained in Table 3 of this report. A 100-year flood event would also cause widespread shut downs of food stores and shopping centers. Many residences, commercial-industrial facilities and access routes would be affected, some seriously. In Dalton, Massachusetts a housing complex for the elderly would receive extensive flooding. In an emergency, evacuation efforts there would be hindered because the single access road to the complex would be inundated. Lives could be lost in this situation.

A number of waste treatment plants could be affected by flooding. Should these plants be inundated, it is possible that untreated or partially treated wastes could spill into the Housatonic River, causing significant health problems.

To help solve the flooding problems and meet the needs of the communities, structural and nonstructural measures were evaluated. Measures studied in detail include dams, dikes, diversions, channel improvements, flood proofing, flood warning and evacuation, flood plain regulations, flood insurance and acquisition. Damage throughout the basin is too scattered to warrant economic justification of structural improvements. Flood insurance, flood proofing and flood warning and evacuation were deemed feasible for further study.

Flood plain zoning is a local responsibility and due to the fact that each city and town is in the flood insurance program it is assumed that the communities are complying with the requirements of that program. Twelve of the fourteen communities studied in detail are currently in the Regular phase and the remaining two are in the Emergency phase.

Flood insurance coverage itself varies throughout the basin however property owners in Massachusetts and in northern Connecticut are the least insured relative to their risk. Increased use of flood insurance in these communities should be encouraged.

Preliminary evaluations indicate that flood proofing measures consisting of raising structures or building utility rooms are feasible at almost 100 residential properties located in Pittsfield and Lee, Massachusetts and New Milford and Seymour, Connecticut. Estimates of first costs for these residential measures total about 2 million dollars with an aggregate benefit-cost ratio of about 1.8 to 1.0.

The potential for flood proofing commercial-industrial structures was evaluated and a total of 155 structures were identified as worthy of further consideration. Candidates are located in 12 of the 14 municipalities selected for detailed study.

Detailed benefit-cost ratios for each commercial-industrial structure were not determined, as that is beyond the scope of this Stage 2 study. Preliminary evaluations indicate that each will have a benefit-cost ratio greater than unity.

To enhance flood preparedness within the basin, three ALERT flood forecast systems are considered feasible. One network would serve the Massachusetts portion of the basin and provide an additional 4.5 hours warning time to Pittsfield and points downstream. Another system would function for the upper Housatonic Basin communities in Connecticut and provide an estimated 9.5 hours lead time on the Housatonic River near New Milford, Connecticut. The third system would be for the Still River in Danbury, Connecticut and provide about 3.5 hours of lead time for that river. In total the implementation costs for the three systems is about $100,000 with an annual operation and maintenance cost of about $5,000. Due to the extremely low cost of these systems the benefit-cost ratios will be high. They also provide adequate warning to those areas identified earlier as having a potential for loss of life.

This report recommends that the Housatonic Urban Study authority be terminated, as there are no water supply problems requiring Federal assistance and since the flood control needs are scattered throughout the basin and can best be considered under Section 205, Small Projects Study Authority, individual study of these areas be pursued at the request of the municipalities involved.

HOUSATONIC URBAN STUDY

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INTRODUCTION

AUTHORITY

Authority for the Housatonic Urban Study is vested in three outstanding resolutions (Appendix A) adopted by the Committee on Public Works of the United States Senate and House of Representatives, which were combined for study purposes.

SCOPE OF THE STUDY

The Housatonic Urban Study focuses on the water supply and flood damage problems in the study area. The study evaluates all feasible alternative plans for providing adequate water supplies to the region and protecting flood-prone areas and preventing flood damages. Costs, benefits and environmental impacts of the various alternatives were investigated. As a result of the Urban Studies guidelines, this report does not recommend a final plan but presents and evaluates an array of feasible alternative plans.

The level of detail in investigating the alternatives described in this report is appropriate for Stage 2 planning. Individual components in the alternatives are at a compatible level of detail so as to assure an equal assessment of associated impacts. The methodologies and plans presented in this report have been formulated and evaluated in close coordination with other governmental agencies, interest groups and interested individuals.

A screening process was employed to eliminate all unfeasible alternatives based on economic, social and environmental impacts. This process developed a preliminary range of solutions to a level of detailed assessment and evaluation sufficient enough to determine the scope and direction of further planning efforts.

STUDY PARTICIPANTS AND COORDINATION

The U.S. Army Corps of Engineers was given the responsiblity for conducting and coordinating the Housatonic Urban Study. The preparation of this report has utilized information developed in other Corps investigations and studies conducted by other agencies.

The studies and investigations for this report were prepared with the cooperation of a large number of agencies, included in these agencies were the following:

Federal Agencies

U.S. Fish and Wildlife Service (F&WS)
U.S. Geological Survey (USGS)
Soil Conservation Service (SCS)

State Agencies

Connecticut Governor's Office
Connecticut Dept. of Environmental Protection (DEP)
Connecticut Dept. of Health Services (DOHS)
Connecticut Office of Policy and Management (OPM)
Connecticut Dept. of Public Utility Control (DPUC)
Massachusetts Dept. of Environmental Quality Engineering (DEQE)
Massachusetts Water Resources Commission (WRC)

Regional Agencies

Berkshire County Regional Planning Commission
Housatonic Valley Council of Elected Officials
Valley Regional Planning Agency
Northwestern Connecticut Regional Planning Agency
South Western Regional Planning Agency
Central Naugatuck Valley Regional Planning Agency
Greater Bridgeport Regional Planning Agency

Local Interests

Western Connecticut Water Supply Council
Housatonic Valley Association.

The study effort provided the opportunity for direct participation and coordination by Federal, State, regional and local agencies as well as interested citizens groups. As a means of encouraging full participation by all sectors of the public, several series of formal public workshops and informational meetings were held throughout the study area to discuss alternative plans.

Coordination with the Connecticut Department of Environmental Protection, Department of Health Services and Office of Policy and Management has been maintained throughout the study. Meetings have been held at various stages to discuss the methodologies and assumptions utilized to develop the alternative plans as well as to keep them abreast of study progress.

THE REPORT AND STUDY PROCESS

In the interest of clarity of presentation, this report has been arranged into a main report and three appendices.

The Main Report is the basic document which presents a summary of the overall planning process and study results for the benefit of both general and technical readers. It includes a description of problems and needs, plan formulation procedures and an assessment and evaluation of each plan's social, economic and environmental impacts.

The technical appendicies present supporting data and specific details of various elements of the study. The report is contained as follows:

Main Report
Appendix A - Problem Identification
Appendix B - Plan Formulation
Appendix C - Technical

The urban study process that culminates in the report is divided into two stages: Stage 1 - Reconnaissance Report and Stage 2 - Development of Intermediate Alternatives.

Each of the two planning stages incorporates four functional planning tasks which become progressively more detailed. The tasks are problem identification, formulation of alternatives, impact assessment and evaluation.

Problem identification entails several procedures. Identifying public concerns, analyzing resource management problems, defining the study area, describing the base conditions, projecting future conditions, and establishing planning objectives are all elements which are addressed to determine the range of water resources problems a study will investigate.

The second planning task, formulation of alternatives, involves developing different resource management plans comprehensive enough to address the planning objectives and to satisfy future water-related requirements.

Impact assessment identifies and measures the types of impacts caused by various alternatives and estimates the incidence of these impacts.

The fourth planning task, evaluation, is undertaken to analyze the impacts. Evaluation criteria such as public acceptability, completeness, effectiveness, efficiency and benefits versus costs are established, and an analysis is performed to determine each alternative's total impact.

PROBLEM IDENTIFICATION

In this section, background information about existing conditions is resented along with a scenario of conditions expected to occur without any Federal action. This information is analyzed to identify problems, needs and opportunities for the study area, from which Federal objectives can be set. Planning objectives and constraints then follow from the problems, conditions, and goals identified.

A more detailed description of the information in this section is given in Appendix A, "Problem Identification".

FEDERAL OBJECTIVES

The Federal objective of water and related land resources planning, as defined by the Principles and Guidelines published in the Federal Register on 22 March 1982, is "to contribute to National Economic Development (NED) consistent with protecting the Nation's environment pursuant to National environmental status, applicable executive orders and other Federal planning requirements." Environmental Quality (EQ) considerations must continue to be an integral component of comprehensive planning.

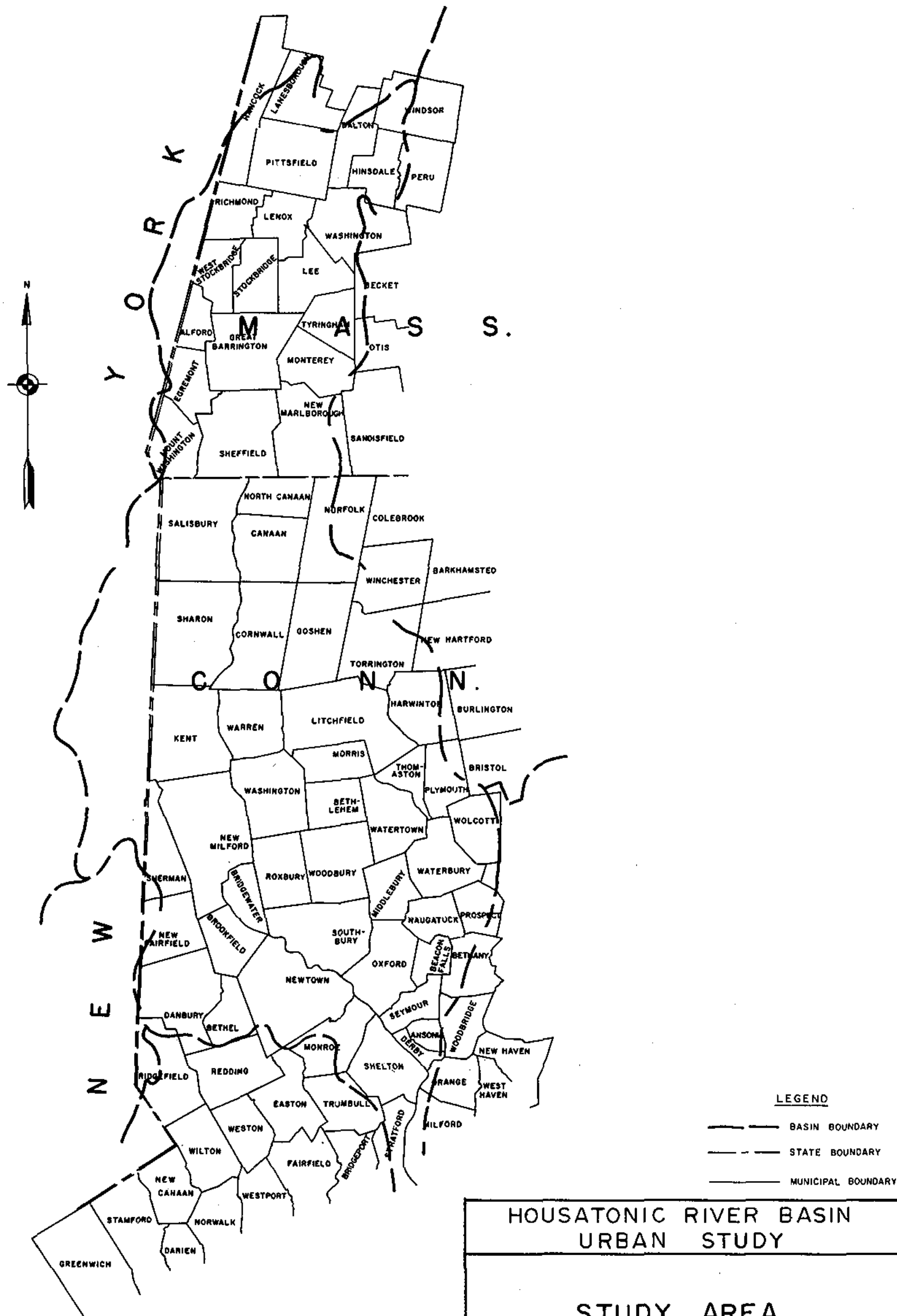
The NED objective can be achieved by various project purposes in the study area. Flood control measures can improve the area economy by reducing flood damages and the resulting costs to businesses in the area's flood plains. Solving water supply problems allows residential, commercial and industrial growth in the study area to continue as projected. Water using industries will not be forced to relocate, and new residential and commercial developments will not be restricted by lack of water. Achievement of these projections can lead to increased growth in the work force and per capita income of the area.

Within the NED objective, EQ considerations can be achieved by the same project purposes, if properly applied. Flood control measures that include or allow preservation of ecologically valuable wetland areas could be adopted. Watershed management measures can increase ecological diversity and productivity of fish and wildlife in the area surrounding surface water development, as well as improve water quality in the impoundment. Recreational development at surface water sites can achieve both EQ and NED aims by increasing or preserving the aesthetic and cultural resources, and by providing recreational opportunities allowing relaxation and thus increasing worker productivity.

EXISTING CONDITIONS

Study Area

The Housatonic River Basin lies principally in the western part of Connecticut and the southwestern corner of Massachusetts with a small portion extending into eastern New York (Plate 1). It is bordered on the



HOUSATONIC RIVER BASIN
URBAN STUDY

STUDY AREA

NOT TO SCALE

PLATE I

west and north by the Hudson River watershed, on the east by the Connecticut River Basin, and on the south and southeast by the Connecticut Coastal Area. The basin is roughly elliptical in shape with a maximum width in an east-west direction of 35 miles and maximum length in a north-south direction of 98 miles. It comprises an area of 1,950 square miles of which 1,232 are in Connecticut, 500 in Massachusetts and 218 in New York.

The Housatonic River, following a southerly course from Pittsfield, Massachusetts, through Connecticut to Long Island Sound, is approximately 132 miles long and has a total fall of 959 feet. Major tributaries include the Naugatuck, Shepaug, Pomperaug and Still Rivers.

The study area, limited to the area within Connecticut and Massachusetts, includes the upper, middle and lower portions of the Housatonic Basin and the major tributaries mentioned above. Five planning regions are located within the study area and three Regional Planning Agencies (RPA's) encompassing the metropolitan areas of Bridgeport, New Haven and Bristol, exist on the study area's periphery.

Fourteen communities in Southwestern Connecticut - Bridgeport, Darien Easton, Fairfield, Greenwich, New Canaan, Norwalk, Redding, Ridgefield, Stamford, Trumbull, Weston, Westport and Wilton - have been added to the water supply portion of the study because of the major impact of their potential demands on the basin's resources.

Topography, Geology and Climate

The Housatonic River Basin consists of rolling hills with steep-sided mountains rising to elevations of 2600 feet around the northern perimeter. The relief becomes more moderate in the middle portion of the basin which has elevations from 1200 to 1500 feet. In the lower area, the even crested hills rise approximately 500 feet above the valley floor. The sloped topography and narrow flood plains in the northern and middle portions of the basin have limited development to small villages, with the exception of Pittsfield, Massachusetts and Torrington, Connecticut, which are built on large flood plains at the confluence of major rivers. The more moderate topography comprising the lower Housatonic and Naugatuck Basins has allowed these areas to develop as major population and manufacturing centers.

The bedrock of the region consists primarily of gneiss, schist and marble. In the upper and middle portions of the Housatonic Basin 5 to 10 percent of the land is exposed bedrock and 25 to 30 percent of the land has bedrock within 10 to 15 feet of the surface. Glacially influenced, hard pan soils are found in both sparsely and densely settled areas where, as in the case of the latter, poorly drained soils contribute to a high rate of septic tank failures. Scattered deposits of sand and gravel, particularly along the rivers, are potentially good water supply aquifers.

The average annual temperature in the basin varies from 50°F near Long Island Sound to 44°F at points in the northern portion. Average annual rainfall varies from approximately 47 inches on the coast to about 44 inches to Pittsfield, Massachusetts. The average annual runoff for the basin is 22.5 inches a year, almost one-half of the average annual precipitation.

Droughts

When rainfall is below average for a period of time, the area experiences what is referred to as drought conditions. A drought is defined as a prolonged period of precipitation deficiency which seriously affects both river flows and groundwater supplies. The 1961-1967 drought in southern New England was one of the greatest ever experienced, the last comparable drought to it was in 1914-1916. The most recent drought to effect the study area occurred in 1980-1981. The total rainfall in the southwestern Connecticut area between August 1980 and August 1981 was less than 33 inches, which is well below the average 47 inches.

Floods

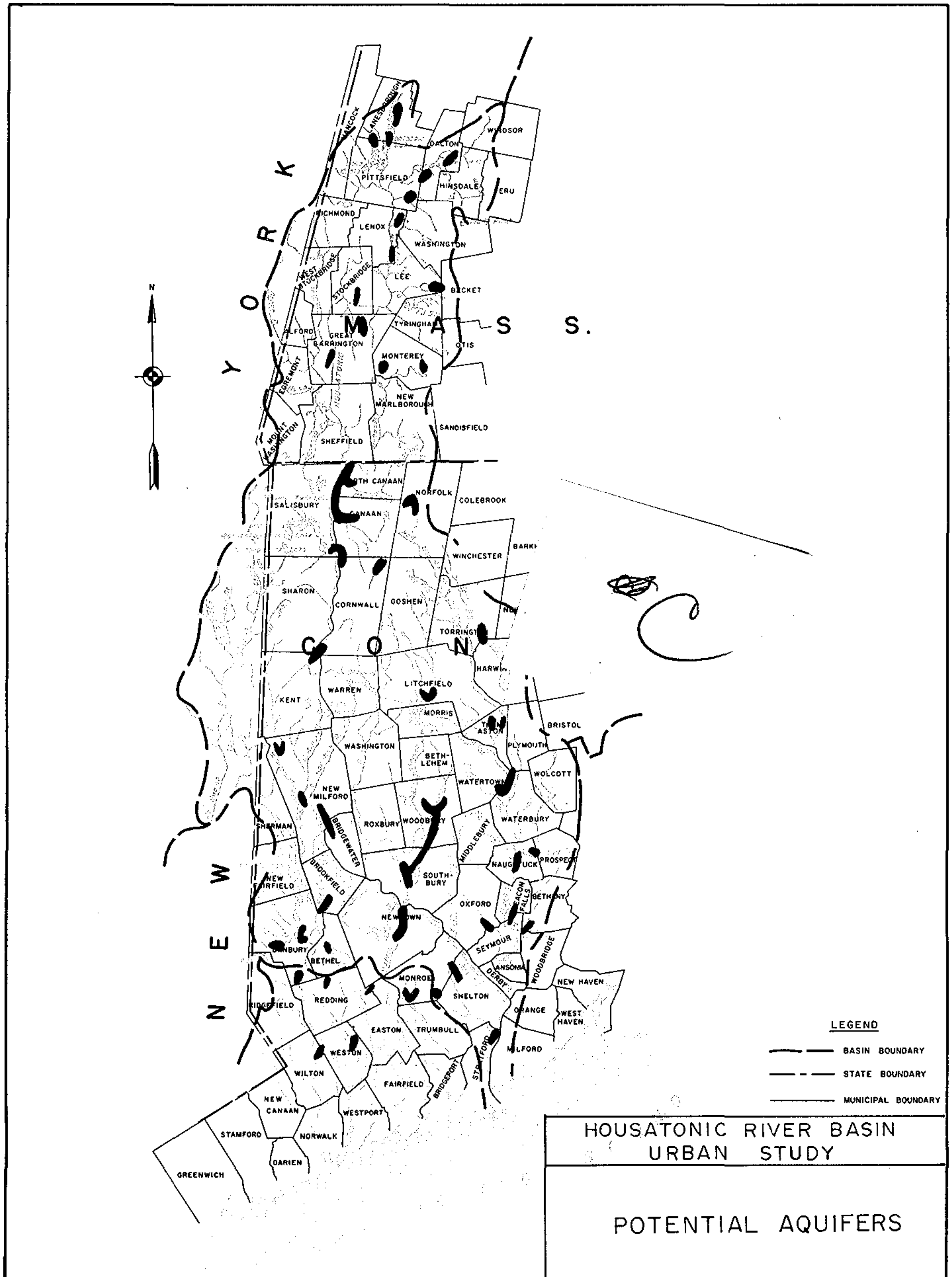
Flooding can occur in the Housatonic Basin at any time of the year as a result of intense rainfall or in the winter or spring due to rainfall combined with snowmelt. The heaviest flood damage potential is concentrated along the mainstem Housatonic River and the Still River. Flood damage surveys have shown that the heaviest flood losses would occur in Dalton, Pittsfield, Lee, New Milford, Danbury, Brookfield and Shelton. Some of the most severe floods that have occurred in the last century were in 1927, 1936, 1938, 1948-49, 1955, 1969, 1973 and 1977. The most recent flooding in Connecticut occurred as the result of a storm in June 1982. The flooding had a record frequency of up to a 15-year event in parts of the Housatonic Basin. In some other basins in Connecticut the storm produced flooding equal to a 200-year event.

NATURAL RESOURCES

Groundwater

In many areas sand and gravel aquifers are present and there appears to be substantial amounts of groundwater, especially where the aquifers include or are bordered by streams. The fact that high yield potentials exist in certain parts of the basin, however, does not necessarily imply that ample supplies of groundwater can be delivered on demand to need areas. Distance of transport and water quality considerations limit the availability of groundwater. Unfortunately, salt water intrusion and/or pollutants generated by increased urbanization have resulted in several aquifers of substandard quality existing throughout the study area.

Groundwater aquifers, shown on Plate 2, in much of the study area have been investigated by the United States Geological Survey (USGS) and



HOUSATONIC RIVER BASIN
URBAN STUDY

POTENTIAL AQUIFERS

NOT TO SCALE

PLATE 2

various agencies and firms in both States. Reports of these agencies and other hydrogeologic reports serve as reference sources for the groundwater assessment included in Appendix C. The scope of the study did not allow for field exploration or field testing of estimated yields.

Water Supply

Within the water supply study area there are 146 water systems serving over 975,000 people in 61 communities. Most of the systems, 131, are in Connecticut and presently serve an average of 150 million gallons of water per day. However, 67 are located in the four communities surrounding Candlewood Lake and some supply water only during the summer recreation season. The largest of the water suppliers in the Connecticut portion of the study area is the Bridgeport Hydraulic Company, which serves 65 million gallons per day to over 360,000 people in 13 communities.

In Massachusetts, 15 water companies serve a total of 18 million gallons per day. The largest company in Massachusetts is the Pittsfield Water Department, which serves over 13 million gallons per day to over 52,000 people. A more detailed discussion of the water companies throughout the basin is contained in Appendix A.

Water Quality

A major pollution problem in the Housatonic from Pittsfield to and including Lake Zoar is the presence of high levels of toxic PCB (Polychlorinated Biphenyls) compounds which were discharged primarily from the General Electric plant in Pittsfield from the early 1930s until 1977, and now continue to enter the environment from landfills, runoff and sediments. Since these compounds have low solubility, they do not significantly affect water quality. However, they have become concentrated in fine-grained bottom sediments and fish tissue at levels much higher than the maximum tolerance level set by the Food and Drug Administration. As a result, both Massachusetts and Connecticut have issued public health warnings against the consumption of fish taken from the river. The Connecticut DEP has temporarily downgraded its classification of that section of the river from a B_S to a D.

SOCIO-ECONOMIC PROFILE

Land Use

Over 65 percent of the total land area in the basin has been classified as open/woodland area. The agricultural acreage is the next largest classification with over 10 percent of the land area (see Table 1). More development has been occurring in the suburbs than in the central cities. Growth is expected to continue in residential acreage using land currently undeveloped.

Population Characteristics

The 19 communities in the Massachusetts portion of the basin experienced a 6 percent increase in population between 1960 and 1970 even though Pittsfield and New Marlborough decreased in population. In the 10 year period between 1970 and 1980, the overall population decreased by almost 3,500 people, with Dalton, Great Barrington, Lee, Pittsfield and West Stockbridge losing people. Pittsfield lost less than 1,000 people from 1960-1970 and almost 6,000 from 1970-1980. The total population for the Massachusetts portion of the basin for 1960, 1970 and 1980 was 94,828, 100,584 and 97,099, respectively.

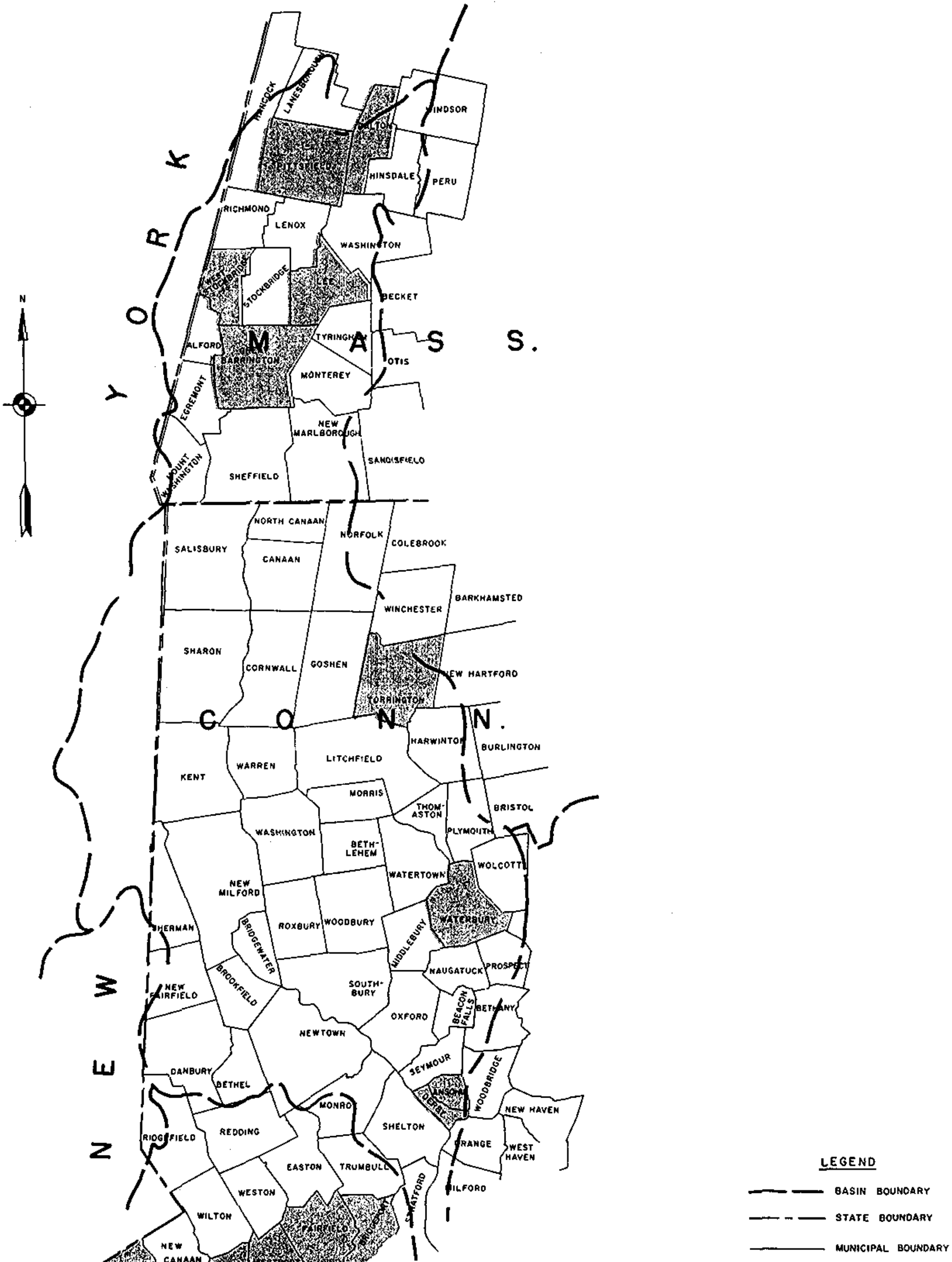
The 44 communities in the Connecticut portion of the Housatonic Basin experienced an increase in total population for both periods 1960-1970 and 1970-1980. The major difference is the percentage increase was almost 50% higher for the 1960-1970 period. The total population for 1960, 1970 and 1980 for the Connecticut portion of the basin was 483,259, 554,587 and 635,200, respectively.

Table 1: 1970 Land Use Data Housatonic River Basin

	% of Total		
Land Types	Massachusetts	Connecticut	Total
1. Residential	4.0	12.5	9.8
2. Industrial	.2	.6	.4
3. Commercial	.4	1.0	.8
4. Transportation, Communication & Utilities	1.3	.6	.8
5. Resource Extraction	.4	.1	.2
6. Institutional	.9	.3	.5
7. Recreational	17.4	1.5	6.2
8. Wetlands		4.9	3.3
9. Water	1.9	2.0	2.0
10. Open/Woodland	63.9	65.7	65.6
11. Agriculture	9.6	10.8	10.4
Total	100	100	100

There are 14 communities in the southwestern portion of Connecticut which have been added to the water supply portion of the study area. This area has experienced a 3 percent decrease in population in the past 10 years. The total population for these communities was 517,424, 607,021 and 589,284 in 1960, 1970 and 1980, respectively.

As shown on Plate 3, 16 of the communities in the study area have had population decreases. Throughout the entire study area, three communities



HOUSATONIC RIVER BASIN
URBAN STUDY

POPULATION DECREASE
(1970-1980)

NOT TO SCALE

PLATE 3

have populations over 100,000 people; Bridgeport, Stamford and Waterbury and seven have between 50,000 and 100,000 people; Pittsfield, Danbury, Milford, Stratford, Fairfield, Greenwich and Norwalk.

The average density of population in 1980 for the entire study area was 642 people per square mile; 790 people per square mile in Connecticut and 180 in Massachusetts. Sixteen of the study area's communities have population densities over 1,000 people per square mile. These communities are generally concentrated along the southern portion of the study area. with the exception of Pittsfield in Massachusetts. Overall, densities ranged from a low of four persons per square mile in Mt. Washington, Massachusetts to a high of 8,848 persons in Bridgeport, Connecticut.

WITHOUT PROJECT CONDITIONS

This section describes the most probable future expected for the study area under the assumption that no new water resources projects will be developed in the Housatonic River Basin.

Water Supply Problem Identification

Projections of population and economic growth for the study area, making up the without condition profile, show that increasing water supply demands within the study area will exceed the capacities of many water supply systems in the near future.

Projections of water demands were based on estimates of population, percentage of the population served, per capita consumption, and industrial water use. These parameters were projected based on historical data and assumptions of future growth trends. The percentage of population served to population was assumed to remain constant through the year 2030. Per capita consumption was assumed to increase throughout the study period by one half gallon per capita per day per year. It was assumed for study purposes that no significant increases in water usage by existing industries would occur and no major new water using industries would move into the study area. A complete description of the water demand projection methodology used is given in Appendix A, "Problem Identification".

Most of the 131 water systems in the Connecticut portion of the basin are very small community or neighborhood type systems with little potential for expansion in the future. Some of these systems are only operated during the summer recreational season. As a result it was considered beyond the scope of this study to investigate alternative management measures or possible regionalization of the smaller systems.

The projected water demands for the areas, shown on Table 2, are based on the "most probable future" and the methodology as outlined. Based on the study area's 1980 safe yields, the deficits for the Connecticut portion of the study area were about 0.6 mgd in 1980, 2.98 in the year 2000 and about 19 mgd in 2030. In the Massachusetts portion of the basin the 1980 deficit was .44 mgd, the 2000 deficit 1.02 mgd and the 2030 deficit 6.78 mgd. These projections are based on the assumption that the existing resources of the various water utilities will be maintained and not discontinued from use.

The deficits described above are significant, and some action must be taken to meet the water supply needs of the study area by increasing supplies and/or reducing demand. Development of surface water and groundwater resources are among the opportunities available for increasing supplies and demand reduction will be addressed through water conservation techniques.

Flood Problem Identification

Flooding in the Housatonic River Basin, which occurs primarily from runoff caused by precipitation of high intensity or prolonged duration, has adverse effects on the economy and general well-being of the flood prone areas. Flooding causes physical damage to property, nonphysical losses associated with interruptions of commercial, industrial and public activities, loss of business and personal income, and also threatens the health and safety of residents and workers in flood-prone areas.

Potential flood damage areas were determined through analysis of the 100-year flood plain, delineated on the most accurate mapping available. The structures found within the flood plain were grouped into two categories, commercial/industrial establishments and residential buildings.

More than half of the total structures plus a majority of the commercial/industrial structures are located along the mainstem of the Housatonic River. The remaining buildings are located within the 100-year flood plains associated with the tributaries to the Housatonic River. In Massachusetts, the remaining flood damage areas in Dalton and Pittsfield are located on the East Branch of the Housatonic River. In Connecticut, the remaining flood damage areas in Brookfield and Danbury are located along the Still River, in Shelton along the Means Brook, in Watertown along the Steel Brook and in Thomaston and Torrington along the branches of the Naugatuck River.

Table 3 identifies the number of structures within the 100-year flood plain by town. They have been split into two categories, commercial/industrial and residential. A total of 3,758 structures, 3,278 residential and 507 commercial or industrial were identified within the 100-year flood plain. Appendix A has a detailed discussion of the potential flood problem in each community.

TABLE 2

WATER SUPPLY NEEDS - CONNECTICUT
(Most Probable Future)

Water Utility	1980 Safe Yield	1980 Avg. Day Demand	1980 Deficit	2000 Avg. Day Demand	2000 Deficit	2030 Avg. Day Demand	2030 Deficit
Kent Water Co.	(1)	.068		.13		.19	
Litchfield Div., LCWC	(1)	.26		.29		.35	
Cornwall Div., LCWC	(1)	.022		.028		.035	
N. Canaan Div., LCWC	(1)	.325		.35		.41	
Lakeville Div., LCWC	(1)	.34		.38		.48	
Thomaston Div., CWC	1.05	.6		.72		.98	
Torrington Water Co.	4.78	3.88		4.07		5.25	.47
Sharon Water & Sewer Comm	(1)	.205		.23		.34	
Waterbury Water Dept.	28.3	16.4		17.9		22.7	
Watertown Water & Sewer	*	.935		1.01		1.45	
Watertown Fire Dist.	2.5	.828		.99		1.41	
Woodbury Water Co.	.8	.13		.168		.212	
Naugatuck Division, CWC	4.77	3.7		3.61		4.95	.18
New Milford Water Co.	2.04	1.12		1.4		1.7	
Danbury Water Dept.	8.6	7.2		8.8	.2	11.4	2.8
Bethel Water Dept.	1.52	1.1		1.5		2.0	.48
Ridgefield Water Supply Co	.77	.75		1.05	.28	1.47	.7
Newton Water Co.	.5	.31		.45		.61	.11
New Canaan Water Co.	1.37	1.06		1.35		1.65	.28
Norwalk 1st Taxing Dist.	6.0	5.92		6.9	.9	8.8	2.8
Norwalk 2nd Taxing Dist.	4.5**	5.1	.6	5.8	1.3	7.5	3.0
Greenwich Div., CAWC	17.0	16.7		17.3	.3	19.6	2.6
Ansonia-Derby Water Co.	6.7	5.64		6.28		7.2	.5
Heritage Village	2.0	1.0		1.71		2.1	.1
Bridgeport Hydralic Co.	76.0	65.5		68.9		76.1	
Canaan Water Dept.	0.03	0.02		0.025		0.03	
Stamford Water Co.	17.5	15.26		17.2		22.5	5.0
Total			0.6		2.98		19.02

*Supply from Waterbury Water Dept.
**Can obtain an additional 3.0 mgd from Bridgeport Hydraulic Company.

(1) These water companies are very small and there is no accurate data available on their sources of supply. Therefore, it is not practical to report their safe yeilds which would be estimates at best. Information available does, however, indicate that the sources are of sufficeint quantity to meet the needs of the system throughout the planning period.

LCWC Litchfield County Water Company
CWC Connecticut Water Company
CAWC Connecticut American Water Company

TABLE 2 (Continued)

WATER SUPPLY NEEDS - MASSACHUSETTS
(Most Probable Future)

		1980		2000		2030	
Water Utility	1980 Safe Yield	Avg. Day Demand	Deficit	Avg. Day Demand	Deficit	Avg. Day Demand	Deficit
Lee Water Dept.	1.14	1.42	0.28	1.61	.47	1.93	.79
Dalton Fire Dist.	2.96	1.5		1.85		2.3	
S. Egremont Water Co.	.19	.155		.23	.04	.35	.16
Lanesborough Village	.864	.205		.28		.41	
Lenox Water Dept.	.64	0.8	0.16	1.04	.4	1.45	.81
Monterey Water Co.	.091	0.013		.02		.034	
Pittsfield Water Dept.	14.7	12.5*		13.4		19.34	4.64
Richmond - Gilchrist Springs	.05	.002		.003		.005	
Sheffield Water Co.	.20	.074		.118		.184	
W. Stockbridge Water Co.	.25	.06		.076		.098	
Hill Water Co.	.02	.005		.007		.011	
Stockbridge Water Dept.	.40	.40		.51	.11	.7	.3
Gt. Barrington Fire Dist.	2.68	1.03		1.25		1.57	
Housatonic Water Works	.6	.28		.36		.49	
New Marlborough	.04	.014		.02		.032	
Hinsdale Water Dept.	0.1	.055		0.096		0.18	0.08
Totals			0.44		1.02		6.78

*Excluding Dalton and Lenox

TABLE 3
INITIAL FLOOD PROBLEM IDENTIFICATION FOR COMMUNITIES
WITHIN THE HOUSATONIC RIVER BASIN

COMMUNITY	AFFECTED STRUCTURES IN FLOODPLAIN COMMERCIAL/INDUSTRIAL	RESIDENTIAL
CONNECTICUT		
Ansonia	0	0
Beacon Falls	7	135
Bethany	0	0
Bethel	3	14
Bethelehem	(No information available regarding	
Bridgewater	0	4
Brookfield	13	10
Canaan	2	18
Cornwall	2	15
Danbury	78	30
Derby	8	19
Goshen	0	3
Harwinton	0	1
Kent	16	14
Litchfield	0	13
Middlebury	0	16
Milford[1]	-	750
Monroe	0	22
Morris	0	0
Naugatuck	35	15
New Fairfield	1	0
New Milford	68	45
Newtown	0	42
Norfolk	0	0
North Canaan	15	100
Oxford	0	30
Plymouth	5	0
Prospect	0	7
Roxbury	0	17
Salisbury	2	55
Seymour	8	90
Sharon	0	15
Shelton	22	40
Sherman	0	0
Southbury	3	20
Stratford[1]	0	750

TABLE 3 (continued)

COMMUNITY	AFFECTED STRUCTURES IN FLOODPLAIN COMMERCIAL/INDUSTRIAL	RESIDENITAL
CONNECTICUT - (cont'd)		
Thomaston	8	20
Torrington	11	38
Warren	8	10
Washington	0	25
Waterbury	0	0
Watertown	8	16
Wolcott	2	0
Woodbury	3	0
MASSACHUSETTS		
Alford	0	10
Dalton	18	8
Egremont	0	40
Great Barrington	15	15
Hinsdale	3	6
Lanesborough	0	40
Lee	22	37
Lenox	1	22
Monterey	3	20
Mount Washington	0	0
New Marlborough	2	45
Pittsfield[2]	108	460
Richmond	0	4
Sheffield	0	60
Stockbridge	7	50
Tyringham	0	15
Washington	0	3
West Stockbridge	0	24
Windsor	0	0
TOTAL	507	3,278

Footnotes:

[1] Both Milford and Stratford have significant coastal flood problems located outside the Housatonic Study area and therefore not investigated in detail for this study.

[2] Only flood problems on the East Branch Housatonic are investigated in this study. Both the West and Southwest Branch Housatonic in Pittsfield have been studied under the Corps' Section 205, Small Projects Authority.

PLANNING CONSTRAINTS

Planning constraints are conditions imposed upon the planning process that limit the range of feasible alternatives available to the planner. These constraints may consist of legal, social and environmental factors of such importance that violating them could compromise the entire planning effort.

One environmental constraint on the planning process is the Wild and Scenic River studies. The Shepaug River is presently being studied and has been recommended for protection under the Wild and Scenic Rivers Act (PL 90-542). This is one of the primary alternative sources which the State has identified for future water supply. Water supply investigations were restricted to the lower end of the river just upstream of its confluence with Lake Lillinonah.

One public policy constraint on the planning process results from the State of Connecticut's law requiring surface water supply sources be free of all sewage discharges. The prohibition of sewage discharges to potable surface water supplies is established by: 1) State law (Section 25-26a of the CT General Statutes, 1971); 2) State regulation (Section 19-13-B 32 of the Public Health Code, 1980); and 3) State policy (CT's Water Quality Standards and Criteria, 1980). These directives were established to provide the maximum amount of protection for drinking water supplies State government could provide. Basic premises to this conservative approach are: 1) There are sufficient quantites of "discharge free" surface water supplies available in CT to meet consumptive demands; 2) The fate of pollutants in water are not entirely understood or predictable; 3) the public health implications for long term exposure to pollutants is not entirely known. Therefore, with the exception of the Shepaug River diversion alternative, all surface water resources that receive treated sewage discharges (Class B water quality) are eliminated from further consideration. It is probably feasible to eliminate sewage discharges into the Shepaug River, but this would further increase the expense to the already high cost estimates for transmission of water from that source. The term sewage is broadly defined by State statute and the Public Health Code and refers to all human excretions and all domestic, agricultural, commercial and manufacturing liquid wastes as may trend to be detrimental to the public health.

PROBLEM AND OPPORTUNITY STATEMENTS

The following problem and opportunity statements were developed with an understanding of the present and future needs of the communities in the Housatonic River Basin. The Corps of Engineers seeks plans that provide solutions for existing flood and water supply problems and also offer the potential for reducing future flood damage and the threat of future water supply deficits within the study area. Wherever possible, these plans will incorporate features that enhance the area's environmental quality.

Based on a preliminary assessment of the water supply and flood problems, needs and opportunities in the study area, the following problem and opportunity statements have been developed.

a. Reduce flood losses in the Housatonic Basin to increase the economic strength and well-being of public, residential, commercial and industrial propety located in the communities that are subject to flooding.

b. Provide greater security for people working and living in the basin whose lives would be threatened in the event of a major flood.

c. Preserve existing and develop additional groundwater and surface water supply resources to meet the projected short-term and long-term residential, commercial, and industrial water supply needs of the study area.

d. Modify water usage within the study area to optimize the usage of existing groundwater and surface water resources.

PLAN FORMULATION

A broad range of management measures were identified and examined. After analyzing the measures with specific technical, environmental, social, and economic criteria, the surviving measures were combined into a range of water resource plans. The preliminary alternatives were compared to each other to ensure a broad mix that addresses the Federal objectives established for the study. The plan formulation process and evaluation criteria are presented in detail in Appendix B, "Plan Formulation."

PLAN FORMULATION RATIONALE

Before discussing the plans that resulted from the preliminary plan formulation, a brief summary of the formulation process and the evaluation criteria used is presented here to brief the reader on the screening process used to arrive at the best alternative plans.

First, all possible measures for meeting the study objectives were identified. Those measures that were obviously unfeasible or unacceptable were removed from further consideration at the outset of the screening. The remaining measures were arranged into various plans to meet the study area's needs.

As the preliminary plans were formulated separately the preliminary plan formulation section is arranged into two parts, water supply and flood control purposes. Formulation and evaluation criteria are common to all purposes, and are presented in a single section. This section is followed by two sections, one for each project purpose, which present management measures and preliminary plan formulation for each project purpose.

FORMULATION AND EVALUATION CRITERIA

Selection of plans of improvement which represent acceptable and justifiable solutions that best respond to the problems and needs of the area entails the application of technical, economic and social criteria to all possible alternatives, including consideration of all beneficial and detrimental effects on the area's environment.

Basically, the plans must be economically sound with a benefit-to-cost ratio near one and be technically feasible. The environmental and social impacts of each plan must be accounted for, and management actions to enhance environmental quality should be identified.

Evaluation criteria were applied broadly at first and then in more detail as plan formulation proceeds towards the selection of detailed plans. A more complete description of the plan formulation process and the formulation and evaluation criteria can be found in Appendix B, "Plan Formulation."

WATER SUPPLY

Management Measures

In formulating alternatives an array of potential measures was investigated. These included nonstructural and structural measures and a No Action Plan. Table 4 lists the measures considered in this initial screening.

TABLE 4

WATER SUPPLY MANAGEMENT MEASURES

Nonstructural Measures	Structural Measures
1. Water Conservation	1. Surface Water Resources
2. Weather Modification	2. Ground Water Resources
3. Direct Wastewater Reuse	3. Dual Water Supply Systems
No Action Program	4. Desalination
	5. Iceberg Harvesting

No Action. The No Action alternative assumes water shortages, if no action is taken by any water supply agency or individual community, would cause adverse socioeconomic impacts on the area by limiting growth to conform to the available supply.

Water Conservation. When the demand for water increases, the usual response is to construct new waterworks facilities. However, an alternative approach is to reduce demand on available supplies. Following are four methods which have been suggested as effective in controlling demands on water supplies.

1. Installing water saving devices.
2. Water conservation education programs.
3. Imposing restrictions on water use.
4. Controlling water system losses.

Each of these methods may be used singly or in combination to achieve a reduction in total water use. The reduction may be an absolute one, in which demand is less than before implementation, or it may be a reduction in the rate of increase of water use.

Water saving devices reduce flows from showers, lavatories and toilets to the minimum necessary to accomplish their purpose. Flow reducing devices can be added to existing fixtures, or replacement fixtures designed to reduce flows can be installed. Some flow reducing devices currently in use include water saving toilets, reduced flush devices, flow limiting shower heads, water conserving dishwashers and clothes washing machines, flow control devices for faucets, and pressure reducing valves to reduce unnecessarily high system pressures.

Modification of water use attitudes and habits can reduce consumption significantly. Education and information campaigns directed toward the consumer can bring about reduced waste in water usage by the voluntary efforts of the educated consumers.

Institutional restrictions are administrative and legislative controls which can be implemented by water suppliers and government agencies to insure public welfare during times of water supply shortages. Some institutional restrictions applicable to the study area are restrictions on domestic water use, water rationing, building and plumbing code restrictions, industrial reclamation and reuse, maintenance, water control inspections, fire hydrant use restrictions, and landscape watering restrictions.

Control of water system losses can be accomplished by a program of leak detection and repair, metering of the entire system, and reduction of illegal uses, such as opening of fire hydrants.

Weather Modification. The primary focus of research in this field is cloud seeding, although long-term seasonal precipitation forecasting and fog drip augmentation are also being studied. However, only cloud seeding is applicable to the Housatonic Study area.

Rain falls from clouds when water vapor in the clouds condenses around particles and forms rain drops large enough to overcome frictional resistance to falling. Cloud seeding is based on the introduction of foreign particles, such as dry ice and silver iodide, into clouds to enhance condensation, producing rain.

Several studies have been made on the feasibility of cloud seeding as a means of augmenting water supplies. The results show that weather modification is an inexact science at best, with much refinement needed before it can be considered a reliable method, and with its ultimate feasibility questionable. Thus, weather modification operations do not appear to provide a viable solution to the study area's water supply problems in the near future.

Direct Wastewater Reuse as a Municipal Supply. Direct wastewater reuse involves returning the effluent from sewage treatment facilities to industrial or municipal supplies. Advanced treatment techniques would be used to attempt to make the effluent safe for human consumption.

Direct wastewater reuse has been successful in industrial process applications in some parts of the country. However, its use for drinking water supply is still lacking in much basic research, and many questions remain. Until this research is completed and appropriate technology is developed, direct wastewater reuse is not a viable alternative to the study area's water supply needs.

Surface Water. Surface water development may be in the form of diversions or impounding streamflow. Larger rivers and lakes may be diverted continuously, while smaller streams may be diverted during high flows only, depending upon the demand and the source's ability to meet it.

Impounding reservoirs, generally on upland streams, may be the most desirable method of supply. Water quality is generally better than from other methods of surface water development.

Ground Water. Ground water storage comprises most of the fresh water stored in the United States and is commonly tapped for water supplies by wells. The most commonly used type is the drilled well, particularly for deep wells when other types are not feasible. Water supplied by wells is generally less likely to need extensive treatment than surface water and is considered less expensive to develop in most cases.

Dual Water Supply Systems. These systems establish a hierarchy of water uses, with higher quality supplies furnished for drinking, cooking, dishwashing, cleaning, bathing and laundering. Other uses would be satisfied by a lesser quality supply.

Dual systems could work by recycling water at the point of usage, with effluent from higher-level uses treated and used for lower level purposes. This approach would involve using two distribution systems to accommodate the two supplies. Potential health problems are inherent in any system that introduces less than potable water into the home environment. This factor, when combined with the high capital cost of dual water supply systems, precludes the use of such systems in the study area.

Desalination. Desalination, the process by which brackish and saltwater is converted to fresh, is currently being used in some parts of the world as an economically feasible source of fresh water. There are four major processes for desalination: distillation - evaporation, membrane separation, crystallization, and chemical differentation. Distillation and membrane separation are most applicable to large-scale operations, according to the present state of the art.

Desalination is already feasible in certain parts of the world where the natural water supply is either scarce or of poor quality, and the relatively high cost of desalination is justified. However, in the study area desalination process costs are much greater than that of possible surface and ground water developments for the near future. Thus, desalination was ruled out as a solution to the study area's water supply problems.

Icebergs. Recent proposals have been made to transport slab icebergs from the polar regions to areas with water shortages. An iceberg would be towed by ocean-going tugboats to the needy area, where it would be melted.

There are many technological problems involved in the use of icebergs as a source of drinking water. These problems must be addressed to bring the high cost of this technology into line with conventional sources, which will not occur until costs from conventional sources increase a great deal. This process does not appear feasible for the near future and was ruled out as a solution to the study area's water supply problems.

Preliminary Screening

The potential measures were evaluated at the outset to rule out those which could not meet even broad criteria for economic feasibility, engineering practicality, social and environmental acceptability, or adequacy as a solution. The preliminary screening showed that water conservation, surface water development, and ground water development warranted further evaluation. The No Action Plan was not considered an appropriate response to the study area's water supply problems and was ruled out at this time.

Intermediate Screening

Those measures which passed the initial screening were considered in more detail before being combined into plans. Surface water and ground water sites for potential development were reviewed individually to determine those which would be most feasible to meet study area needs either separately or as part of an overall plan. Water conservation measures were screened to determine the overall effectiveness of such a program.

Development of Intermediate Alternatives

As a result of reconnaissance and preliminary type estimates, preliminary screening, and analysis of applicable management measures, an array of alternative plans that would address the planning objectives of the Housatonic Urban Study were considered utilizing either one or a combination of the applicable measures for water supply management described in the preceding section. Alternatives were developed that addressed the water supply needs of the study area incorporating both structural and nonstructural measures and focused on the water requirements projected for both short-term (2000) and long-term (2030) planning periods.

A "home rule" approach has long governed development of water supply sources in New England. Because of this traditional approach it was felt that the formulation and evaluation of plans would be more responsive to local officials' and states' needs if conducted on a community-by-community basis. Since in some cases a community may have had more than one alternative which after screening as considered feasible, all feasible options for the communities have been presented.

The following discussion of alternatives is presented in two sections; Connecticut and Massachusetts. All costs presented in this report are preliminary and are used only for comparison of the water supply alternatives being considered. Prior to the selection of a final alternative, careful examination of annual costs, including capitol cost, product cost, operation and maintenance cost, property taxes and depreciation should be made.

Connecticut

Shepaug Diversion. The Shepaug River Diversion (Plate 4) is one of the primary regional water supply alternatives considered for the Housatonic Basin and Southwestern demand centers. There is much concern about its feasibility as a water supply source, associated impacts and total cost.

The Shepaug River is currently classified as a Class "B" river, primarily because it receives discharges which make it unsuitable for use as a drinking water supply source. The present main source of contaminants into the river is the Litchfield Sewage Treatment Plant. If this discharge, along with other smaller ones, were removed, the Shepaug could become a Class "A" river with relative ease and be suitable for public drinking water supply. There is a significant cost to remove these discharges that has not been included in this study.

The feasibility of diverting the Shepaug River near the Roxbury Falls area through a pipeline 38 miles long was investigated. The pipeline would follow major roads to Margerie Lake Reservoir, then on to Trinity Lake, and finally to the Bargh Reservoir. These reservoirs were chosen because they could store large amounts of water without significantly raising the levels of their reservoirs.

Under this plan, water from the Shepaug River would be diverted during the wet months (December through May) only. A maximum diversion of 11 mgd was evaluated for use by the southwestern need areas. This diversion would not affect the potential National Wild and Scenic River Area which is located upstream of the site.

Three alternative plans for diversion of the Shepaug River were evaluated. The first includes diverting 11 mgd: 4 mgd to Danbury, 4.5 mgd to Stamford and 2.5 mgd to Greenwich. The total cost of this plan is over $42 million. The second plan evaluates the possibility of diverting 11 mgd using two phases; 7 mgd in 1990 and 4 mgd in 2010 or as needed. The third alternative plan assumed that Danbury would not utilize any of the water diverted. The water would be stored by Greenwich and Stamford. The Stamford water could then be used to supply some of the other water companies in the southwestern area. The following table identifies the Shepaug Diversion alternatives evaluated.

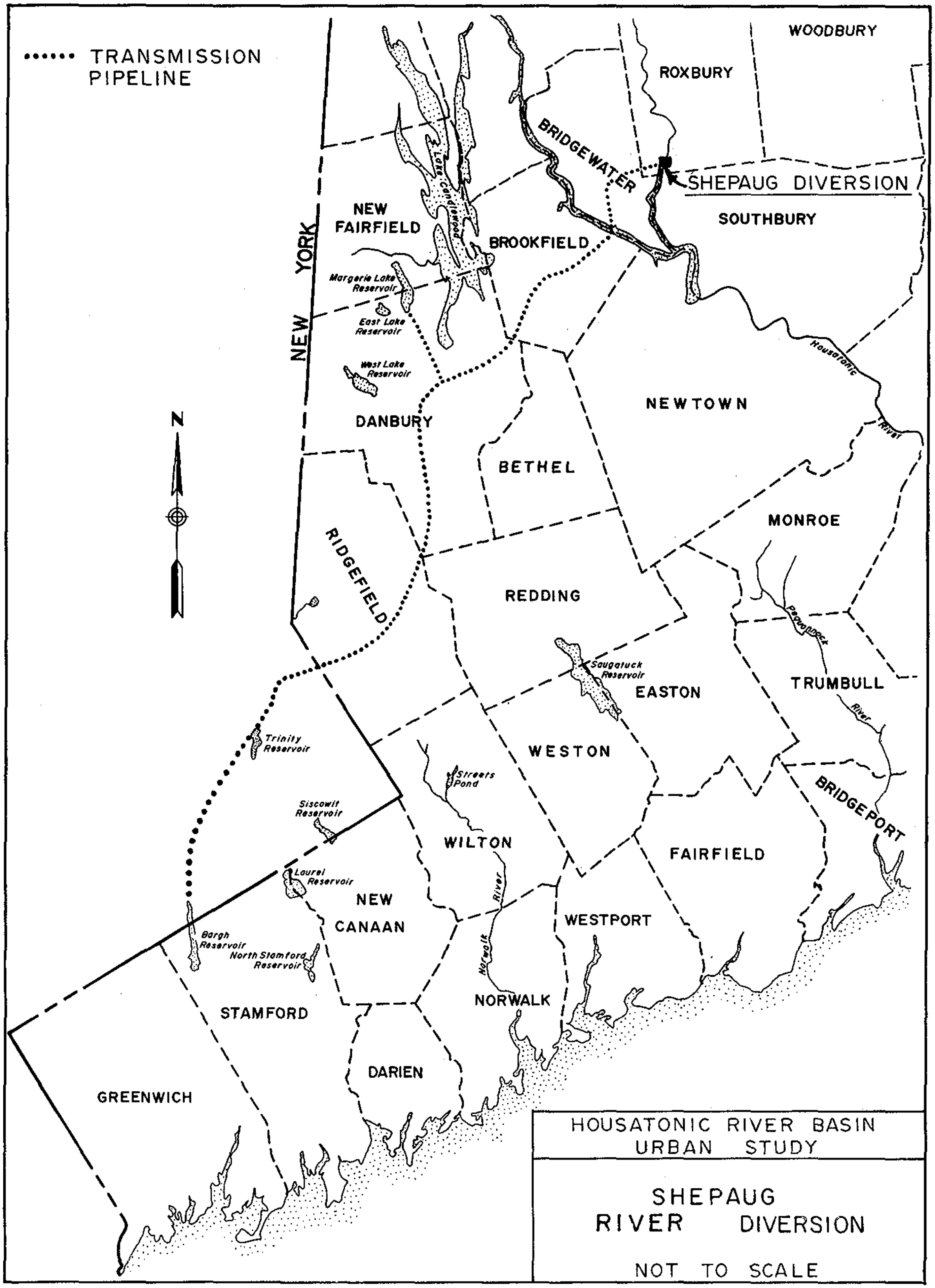

TRANSMISSION PIPELINE
NEW YORK
WOODBURY
ROXBURY
BRIDGEWATER
SHEPAUG DIVERSION
SOUTHBURY
NEW FAIRFIELD
Lake Candlewood
BROOKFIELD
Margerie Lake Reservoir
East Lake Reservoir
West Lake Reservoir
DANBURY
NEWTOWN
Housatonic River
BETHEL
MONROE
RIDGEFIELD
REDDING
Pequonnock
TRUMBULL
River
Saugatuck Reservoir
EASTON
WESTON
Trinity Reservoir
Streets Pond
Siscowit Reservoir
BRIDGEPORT
WILTON
FAIRFIELD
Laurel Reservoir
NEW CANAAN
Norwalk River
WESTPORT
Bargh Reservoir
North Stamford Reservoir
NORWALK
STAMFORD
DARIEN
GREENWICH
HOUSATONIC RIVER BASIN URBAN STUDY
SHEPAUG RIVER DIVERSION
NOT TO SCALE

PLATE 4

SHEPAUG DIVERSION*

	Danbury	Stamford	Greenwich	Total
Alternative 1				
Safe Yield	4 mgd	4.5 mgd	2.5 mgd	11 mgd
Total Cost	$9.2	$18.85	$13.15	$41.2
Avg. Annual Cost	$1.05	$ 2.10	$ 1.25	$4.4
Alternative 2				
Phase 1				
Safe Yield	2.5 mgd	3 mgd	1.5 mgd	7 mgd
Total Cost	$5.65	$14.80	$ 9.05	$29.5
Avg. Annual Cost	$ .65	$ 1.45	$ .80	$2.9
Phase 2				
Safe Yield	1.5 mgd	1.5 mgd	1.0 mgd	4 mgd
Total Cost	$4.10	$10.75	$ 9.70	$24.55
Avg. Annual Cost	$ .085	$ .2	$ .17	.46
Alternative 3				
Phase 1				
Safe Yield		4.5 mgd	1.5 mgd	6 mgd
Total Cost		$22.55	$ 9.15	$31.7
Avg. Annual Cost		$1.8	$ .65	$ 2.45
Phase 2				
Safe Yield		3 mgd	1.5 mgd	4.5 mgd
Total Cost		$16.40	$ 9.85	$26.25
Avg. Annual Cost		$ .25	$ .15	$.4

*All costs in million $; annual costs are based on an interest rate of 7-5/8%.

West Aspetuck River Diversion. The West Aspetuck River is a Class "A" river. It was originally thought that it could be dammed and the impounded water used. However, it became apparent that it was not feasible to dam the river due to the encroachment of surrounding development. Instead, a diversion was examined and it was determined that at least 4.7 mgd of water could be diverted safely through pipelines for use by Danbury, Greenwich, and Stamford. Two plans were investigated, the first supplying water to all three companies, the second supplying water only for use by Danbury. Both plans are shown on the following table.

WEST ASPETUCK RIVER DIVERSION*

	Danbury	Stamford	Greenwich	Total
Plan 1				
Safe Yield	2.2 mgd	1.0 mgd	1.5 mgd	4.7 mgd
Total Cost	$ 6.65	$9.65	$7.6	$23.9
Avg. Annual Cost	$ .65	$ .90	$ .80	$2.35
Plan 2				
Safe Yield	4.7 mgd			4.7 mgd
Total Cost	$14.35			$14.35
Avg. Annual Cost	$ 1.35			$ 1.35

*All costs in million $.

Bridgeport Hydraulic Company Interconnection. Another regional option to increase water supplies for some towns in southwestern Connecticut would be to interconnect with the Bridgeport Hydraulic Company (BHC). The company presently has an excess safe yield of 15 million gallons per day. A staged program for delivery of 12 of this 15 mgd from BHC to the southwestern area can be readily implemented and on a timely basis. By means of existing interconnections, water supplied by BHC can have an impact on water companies as far west as Greenwich.

Beyond the use of current interconnections, a phased program of construction to make up to 12 mgd of additional supply available to the southwest area is proposed as shown in the following table.

Bridgeport Hydraulic Interconnection Capacities

Existing	
Norwalk 1st Taxing District	1.5 mgd
Norwalk 2nd Taxing District	3.0 mgd
Phase 1	
Norwalk 1st Taxing District	1.5 mgd
Norwalk 2nd Taxing District	3.0 mgd
Darien	2.0 mgd
	6.5 mgd
Phase 2	
Norwalk 1st Taxing District	1.5 mgd
Norwalk 2nd Taxing Distrct	3.0 mgd
Stamford	1.0 mgd
Darien	2.0 mgd
New Canaan	1.0 mgd
	8.5 mgd

Phase 3	
Norwalk 1st Taxing District	2.0 mgd
Norwalk 2nd Taxing District	3.0 mgd
Stamford	2.0 mgd
Darien	3.0 mgd
New Canaan	2.0 mgd
	12.0 mgd

Phase I of this plan consists of improvement to the BHC distribution system in Westport, and includes additional pumping capacity at Wilton and a new regulator to deliver additional water in the vicinity of Coleytown. Phase I will increase the water delivery capacity of BHC to 6.5 mgd and cost approximately $100,000.

In Phase II, Bridgeport Hydraulic's existing 24-inch pipeline which presently terminates at Norwalk 2nd reservoir would be extended to Stamford. This would increase the delivery capacity to 8.5 mgd at an approximate cost of $3.1 million. Phase III would complete the total pipeline by connecting the Hemlock supply to the existing pipeline which would increase the delivery capacity to 12 mgd. This phase would cost approximately $5.2 million.

Phase II of this plan, which includes construction of 6 mile long pipeline, could take care of the southwestern areas deficits through the year 2000. Bridgeport Hydraulic would be able to supply this much water without any additional supply. In order for Bridgeport Hydraulic to go into Phase III of this plan and supply all the needs through the year 2030 of the southwestern area, they would have to supplement their supply by approximately 7 mgd. They presently have two possible sources being considered for future use. One is the Trumbull Pond Reservoir, which has a potential safe yield of 7 mgd. And the other is increasing the Housatonic wellfield, which has potential additional safe yield of 9 mgd. Construction of either one of these sources would enable Bridgeport Hydraulic to move into the Phase III plan and take care of their own demands plus the demand of the southwestern area through the year 2030.

Candlewood Lake

Candlewood Lake, the largest body of water in the State, is located in western Connecticut. This lake was built by the Connecticut Light and Power Company in the late 1920's as the upper reservoir of the Rocky River Pumped Storage Project. This generating station and associated project land is licensed by the Federal Energy Regulatory Commission (FERC) as part of Project No. 2576, and subject to the requirements of the FERC license and FERC regulations. The Rocky River generating facility is located at the northern end of the lake and is owned and operated by the Connecticut Light and Power Company. The company pumps Housatonic River water into the lake for storage and later releases it through the generating plant when needed. All runoff into the lake is also utilized by the generating facility.

In addition, water released from Candlewood Lake passes through the turbines at Shepaug and Stevenson Stations located downstream on the Housatonic. Thus, this water generates electricity three times following release from the upper reservoir.

The lake has a surface area of 5,600 acres. Virtually all of the lake bottom and surrounding lands up to elevation 438 are owned by the Connecticut Light and Power Company. Because of its location in relation to major population centers and past land use agreements to utilize power company land, the lake has become a very popular recreational center. The intense development around the lake is primarily summer homes. During the summer months the lake supports a variety of recreational activities including; boating, water skiing, fishing and swimming.

The total drainage area of the streams and brooks entering Candlewood Lake is 32 square miles and the lake has a storage capacity of 172,000 acre-feet. Based on the above data, initial estimates indicate that at least 30 mgd could be withdrawn from the lake. Since inflow is not constant, additional pumping from the Housatonic River would be required during dry periods if the lake level were to be maintained. This additional pumping assumes that water is available in the Housatonic River and does not interfere with generation requirements at Shepaug and Stevenson Stations located downstream along the Housatonic River.

Candlewood Lake was used by the Danbury Water Department as an emegency supply source during the later part of the 1960's drought. There has been much discussion and concern expressed over the possibility of Candlewood Lake being used as a permanent water supply source. Many potential problems arise when evaluating the possibility including the effects on generation at Rocky River Station and Shepaug and Stevenson Stations located downstream.

Candlewood Lake is presently a Class B body of water, due at least in part to the Housatonic River water being pumped into it. This alone precludes it from use as a water supply source, according to existing State laws, policies and regulations as identified in the Planning Constraints section beginning on page 10.

There are restrictions on the types of recreational usage allowed on a body of water used as a supply source. If a body of water is a primary source of supply, which means it is pumped directly into a treatment plant and then to consumers, no contact sports are allowed. Contact sports include activities such as swimming and water skiing, where the body comes in contact with the water. Refer to Section 25-43C of the Connecticut General Statutes entitled, "Permitted Recreation on Watersheds and Reservoirs."

Water quality could also be a problem with the use of Candlewood Lake as a water supply source. Most of the intense development around the lake utilizes septic systems. Many of these systems are designed for seasonal usage, and as cottages are converted to year round homes the systems are susceptible to failure. These failures could cause discharging of waste directly into the lake. Another potential problem arises with the use of Housatonic River water. The river is contaminated with PCBs and has been given a D classification. There may be a chance of PCBs getting into the lake with the increased pumping rate.

The Connecticut Light and Power Company built the lake to generate electricity. If water were withdrawn from the lake for water supply purposes it would effect the operation of this and downstream power projects. The power company would have to be compensated for any losses incurred or addtional pumping costs for water from the Housatonic River to offset that withdrawn for water supply.

The Danbury Water Department has recently added the Lake Kenosia diversion to their water supply system. With the addition of this source the demand for water can be met through the year 2000. At that time they will have to increase their source of supply. If Candlewood Lake were to be used by Danbury, it would only require the addition of a pump station and pipeline. The lake could easily provide for the needs of Danbury through the year 2030.

Another area that could possibly utilize the water would be the Southwestern portion of the State. If this area were to use the lake it would require 24 miles of pipeline to transport the water from Candlewood Lake to the Greenwich-Stamford area. As with the Shepaug River and West Aspetuck River Diversions, long pipelines are very expensive and not cost effective at this time.

In summary, the lake would not be needed as a water supply source until at least the year 2000. As a result fo the lake's location, in relation to the area's major demand centers, it appears as though it would be a cost effective only for the communities surrounding the lake. But, before the lake could be considered as a feasible source, even for the long-term, some significant changes need to be made to existing State laws, policies and regulations. Also, detailed study would be needed to determine the extent of the many impacts associated with the use of Candlewood Lake as a water supply source. For example, what whould be the impact on the Rocky River generating facility and downstream facilities and what compensation would be needed for the amount of water withdrawn? If increased pumping is required from the Housatonic River to offset that withdrawn for water supply, will PCBs and other contaminents become a problem? What will be the effect on the recreational activities in and around the lake? These questions and many more, which are beyond the scope of this study, will need to be addressed before the lake is considered as a source of drinking water.

In view of the finite nature of the States water resources and the growing need for potable water supplies, the watersheds of potable water sources which have been or are proposed to be abandoned from active use, should be evaluated on a case-by-case basis and where feasible these sites should continue to be perserved as open space areas in order to retain the option of future reuse for potable purposes.

These were the major regional alternatives investigated. The remaining alternatives are discussed on a community-by-community basis.

Danbury Water Department

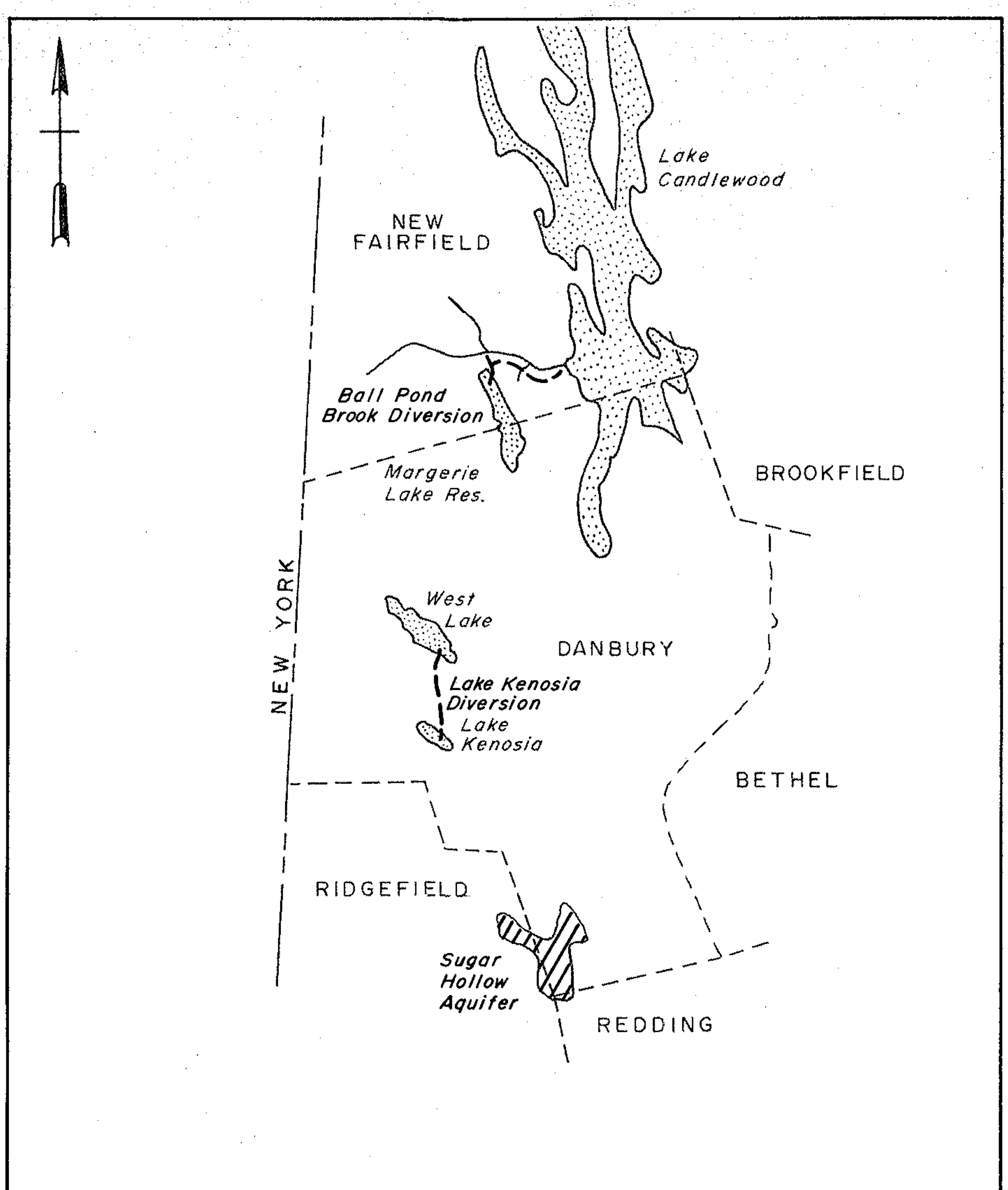
The Danbury Water Department is the major supplier of water to the city of Danbury. It serves 40,000 people, which is over one-half of the total population of Danbury. The present average day demand on the system is 7.2 mgd which is expected to increase to 8.8 mgd by the year 2000 and up to 11.4 mgd by 2030. The projected deficit for 2000 is therefore, 0.2 mgd and for 2030, 2.8 mgd. The following water supply plans have been investigated and evaluated to eliminate these deficits (see Plate 5).

The Ball Pond Brook Diversion is a two phase plan to pump Ball Pond Brook, which is located in New Fairfield, into the existing Margerie Lake Reservoir. Phase I would increase the safe yield of the Danbury system by 1.9 mgd and cost approximately $566,000. Phase II of the plan would include another diversion of Ball Pond Brook near Lake Candlewood. Margerie Lake Reservoir would have to be raised 3 feet to provide adequate storage for the second phase of this plan, which would provide an increased safe yield of 1.8 mgd. The cost of Phase II of this plan would be $4.7 million.

The Sugar Hollow aquifer has the possibility of yielding as much as half a million gallons a day for Danbury. However, this aquifer is located in the watershed of the Saugatuck Reservoir, which is owned by the Bridgeport Hydraulic Company. Jurisdiction over aquifers is a tricky legal question, one which at present does not have many legal precedents. Some cases are now in litigation. Consequently, in order for the Sugar Hollow aquifer to be tapped for Danbury use, this legal ownership question would have to be answered. A wellfield, pump station and transmission main would be required to transport the water to Danbury. The total cost of this plan is estimated to be $372,000.

The Lake Kenosia Diversion, is being added to he Danbury system and has a potential safe yield of 2.1 mgd. The alternative includes construction of a 24 inch transmission main and pump station that will connect with the existing 24 inch transmission main at Kenosia Avenue which runs under I-84 and the railroad to Millplain Road. A new 24 inch force main would then be constructed from Millplain Road past the Western Connecticut State College Campus on Driftway Road and on into West Lake Reservoir.

The following table lists the major alternatives evaluated. The first column identifies the alternative, the second column identifies the



HOUSATONIC RIVER BASIN
URBAN STUDY

DANBURY WATER DEPARTMENT ALTERNATIVES

NOT TO SCALE

PLATE 5

total first cost for the alternatives, the third column identifies the safe yield and the fourth column shows the total cost per million gallons per day.

	Total Cost	Safe Yield	Cost per mgd
Ball Pond Diversion (Phase 1)	$ 566,000	1.9	$ 302,000
Sugar Hollow Aquifer	372,000	0.5	744,000
Ball Pond Diversion (Phase 2)	4,700,000	1.8	2,600,000
Shepaug Diversion	9,200,000	4.0	2,300,000
West Aspetuck Diversion	6,650,000	2.2	3,022,000
Lake Kenosia Diversion	*	2.1	

*Recently added to the Danbury Supply System

Ridgefield Water Company

The Ridgefield Water Company, which is the largest in the town, presently serves about 65 percent of the population. Their existing average day usage is about 0.75 mgd and is expected to increase to about 1.05 mgd by the year 2000 and up to 1.47 mgd by the year 2030. This would cause a deficit of about 0.3 mgd by the year 2000 and 0.7 mgd by the year 2030.

Two groundwater sources were investigated for possible use by the town of Ridgefield, the first being Sugar Hollow Aquifer and the second the Upper Saugatuck Aquifer. Plate 6 shows the location of these two aquifers. The Sugar Hollow Aquifer has a potential yield of about .5 mgd. The total cost of this alternative including pump station, wellfield and transmission main is $478,000.

The Upper Saugatuck Aquifer, which is located in the northern portion of Redding, has approximately a 1.5 square mile area. The area is lightly developed including extensive wetlands, a small retail shopping area at the west end and scattered low density residentials. The aquifer has a potential safe yield of 0.5 mgd. The cost of the wellfield, pump station and transmission main to transport this water to the Ridgefield System is $717,000.

A possible interconnection between Danbury and Ridgefield was also investigated. It was designed to carry up to 1 mgd of water and extend seven miles to interconnect the two systems. The cost of the interconnecting pipeline and pump station is $1,358,000. This cost does not include any cost for water that would have to be bought from the Danbury Water Department.

The following table identifies a major alternatives evaluated for the Ridgefield Water Company.

	Total Cost	Safe Yield	Cost per mgd
Sugar Hollow Aquifer	$ 478,000	0.5	$ 956,000
Upper Saugatuck Aquifer	717,000	0.5	1,434,000
Danbury Interconnection	1,358,000 *	1.0	1,358,000 *

*Does not include the cost of water, only the interconnection with the Danbury Water Department.

Greenwich Division, Connecticut American Water Co.

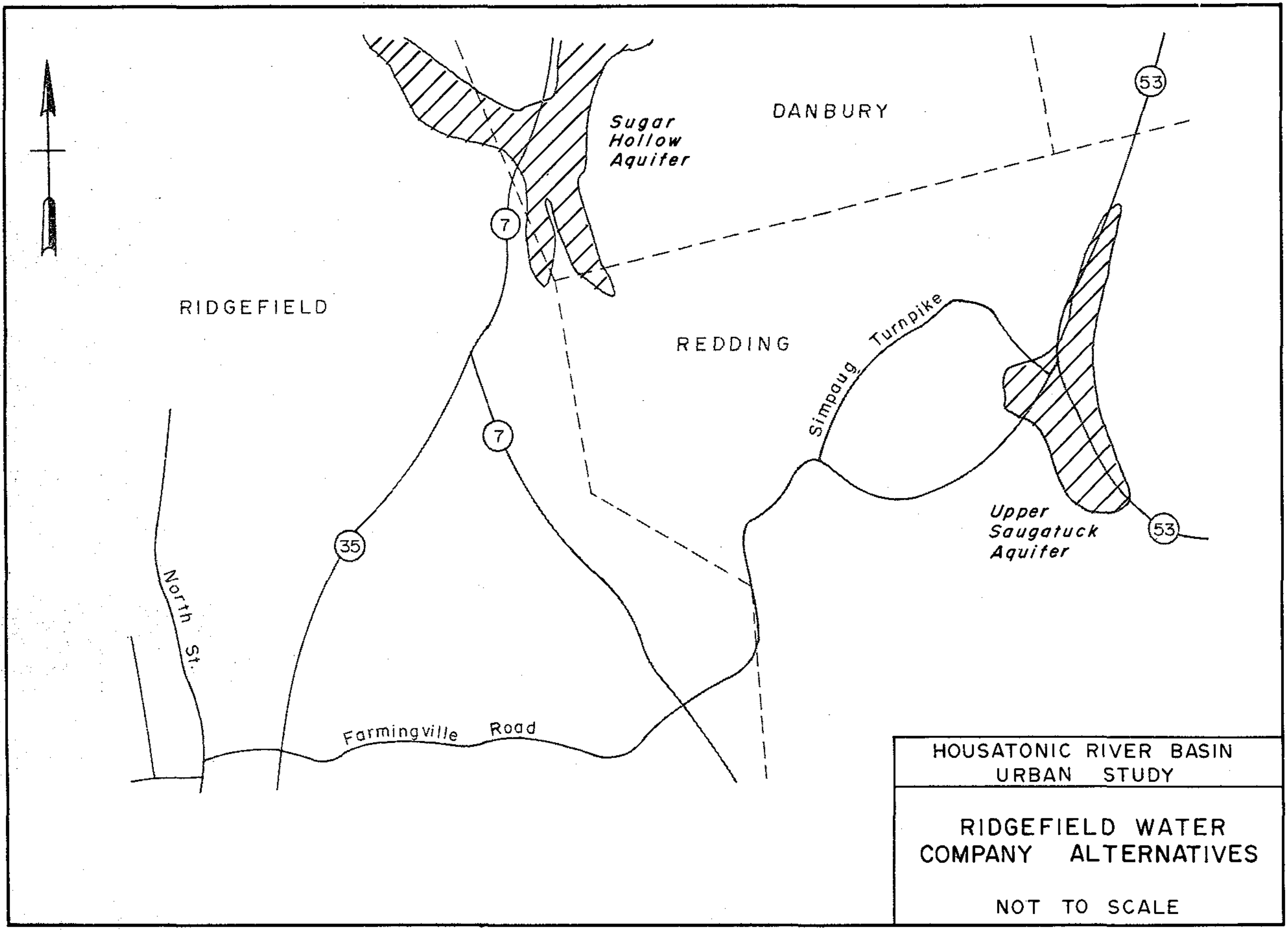
The Greenwich Division supplies water to the town of Greenwich in Connecticut and to Port Chester Water Works Inc., in New York. The present total average day demand is 19.67 mgd of which approximately 7 mgd is sold to Port Chester. The demand for the year 2000 is expected to increase to 17.3 mgd and by 2030 to 19.6 mgd. These projected demands assume that Port Chester will continue to buy 7 mgd from Greenwich. If they do, Greenwich will have a deficit of 2.6 mgd by 2030, as, the present safe yield of the system is approximately 17 mgd.

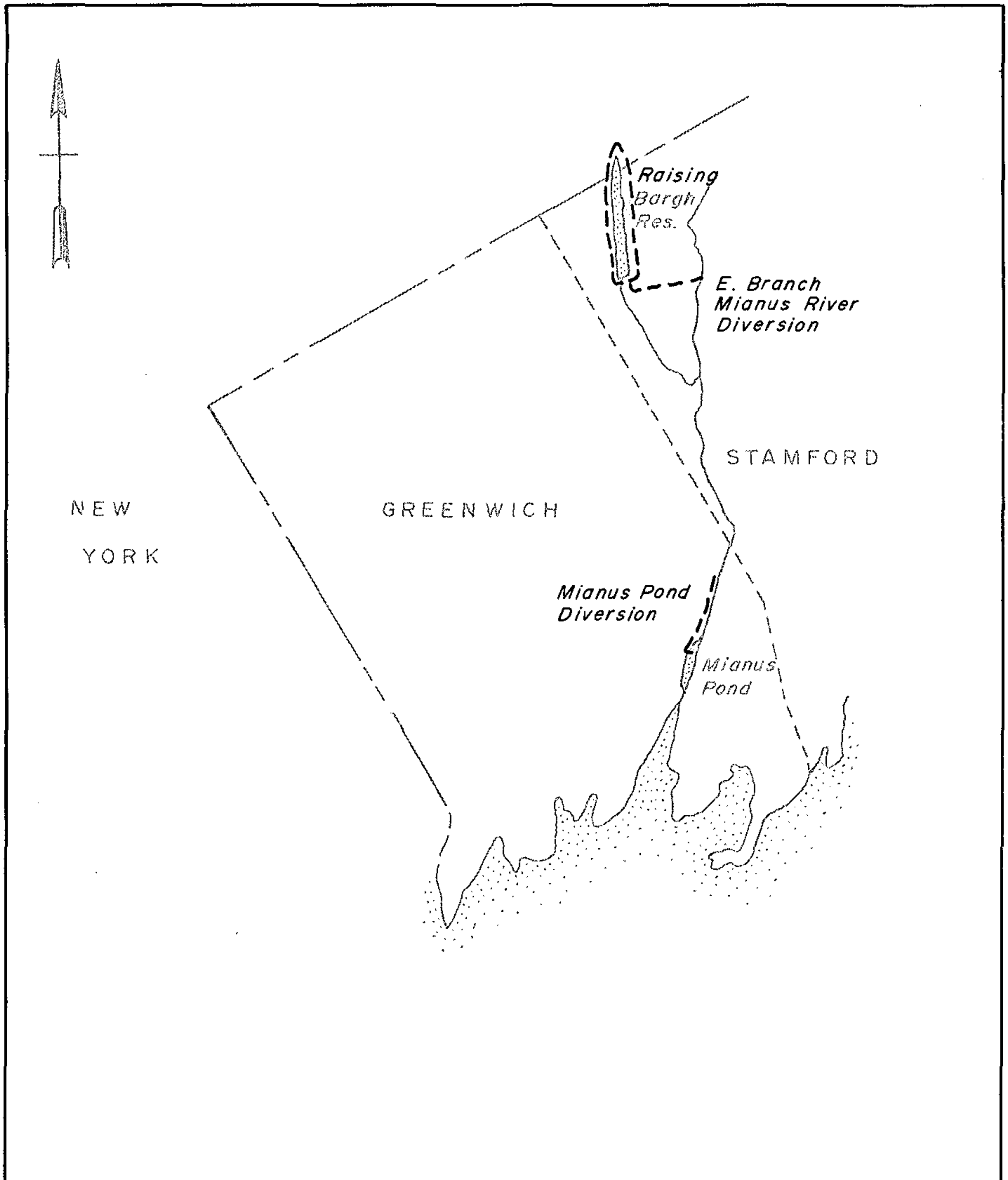
The Mianus Pond (see Plate 7) was investigated as a potential source or future drinking water. The pond is located at the mouth of the Mianus River in Greenwich and is estimated to have a safe yield of approximately 2.5 mgd. There is an existing dam owned by Conrail, but it is expected to be abandoned in the near future. This is presently a Class "A" water body and the Department of Environmental Protection indicates it can be upgraded to Class "AA" through the standard revision process. The alternative plan involves the construction of a transmission main from Mianus Pond to the existing Mianus River Filtration Plant. The total cost of this alternative is $1,020,000 and includes a pump station and transmission main. In order for this alternative to increase the safe yield of the system by the full 2.5 mgd, the existing filtration will have to be expanded and some changes made in the distribution system.

Another alternative investigated is the possible diversion of water from the East Branch of the Mianus River in Stamford into the existing Bargh Reservoir. This alternative could increase the safe yield of the system by as much as 1 mgd. A diversion of this size into the existing system would not require any additional storage. The alternative includes a diversion structure on the East Branch of Mianus River, a pump station, and transmission main to the existing Bargh Reservoir. The total cost of this alternative is about $730,000 and a diversion of this size on the East Branch Mianus River is not expected to cause any severe adverse environmental impacts.

The Bargh Reservoir is a water supply reservoir providing potable water to the residents of Greenwich. Preliminary analysis indicates that a safe yield of 13.2 mgd could be obtained from the 18.3 square mile

PLATE 6


Sugar Hollow Aquifer
DANBURY
53
7
RIDGEFIELD
REDDING
Simpaug Turnpike
7
35
Upper Saugatuck Aquifer
53
North St.
Farmingville Road
HOUSATONIC RIVER BASIN
URBAN STUDY
RIDGEFIELD WATER
COMPANY ALTERNATIVES
NOT TO SCALE



HOUSATONIC RIVER BASIN
URBAN STUDY

GREENWICH WATER
COMPANY ALTERNATIVES

NOT TO SCALE

PLATE 7

drainage area if adequate storage were available in the reservoir. In order to increase the storage of the reservoir, the dam would have to be raised 20 feet to elevation 282. This plan would increase the surface area by 36 acres.

The total cost of the alternative to raise the Bargh Reservoir the required 20 feet is approximately $8.0 million. If built, this plan would have severe social and environmental impacts due to the flooding of a portion of the Mianus Gorge Area. The following table identifies and compares the various alternatives studied for the Greenwich Division.

	Total Cost	Safe Yield	Cost per mgd
Mianus Pond	$ 1,020,000	2.5	$ 408,000
East Branch Mianus River	730,000	1.0	730,000
Raising Bargh Reservoir	8,000,000	3.0	2,666,000
West Aspetuck Diversion	7,580,000	1.5	5,053,000
Shepaug Diversion	13,150,000	2.5	5,260,000

Port Chester Water Works is presently negotiating with Westchester Water Works, also of New York, to buy up to 3 mgd. If they were able to negotiate such a contract, it would relieve Greenwich from a portion of their contact and make the water available for use by Greenwich. The additional 3 mgd would enable Greenwich to meet their needs through the year 2030.

Stamford Water Company

Stamford Water Company delivers water to about 83 percent of the people in Stamford and also supplies water to the Noroton Water Company. The system supplies an average of about 16 million gallons per day, about 15 mgd to Stamford customers and 1 mgd to the Noroton Water Company. The projected demand for the city of Stamford is expected to increase to 16 mgd by 2000 and up to 20.4 mgd by the year 2030. The Stamford system of reservoirs produces a safe yield of 17.5 mgd. This system presently can take care of the needs of the city of Stamford through the year 2000. By the year 2030 the water company will have to increase its safe yield by 3 million gallons a day.

The Siscowit Reservoir is a water supply storage reservoir providing potable water to residents of Stamford and Darien, Connecticut. To meet future needs a plan was investigated to raise the level of the reservoir by 25 feet, consisting of the construction of an earth and rock dam at the site of the existing impoundment (see Plate 8). The top length of the dam would be approximately 1650 feet. In addition, a dike would be constructed with a top length of approximately 650 feet. The elevation at the top of these structures is 482.

The drainage area contributing to the Siscowit Reservoir encompasses a total of 3.4 square miles. It is estimated that this watershed could supply a maximum safe yield of about 2.7 mgd. The Siscowit Reservoir presently yields about 0.7 mgd. With the resulting increased water surface area (175 total acres), it would be necessary to purchase 128 acres of land and relocate three houses. Formulation of this plan indicated a project cost of $9.6 million. A summary of the alternatives investigated for the Stamford Water Company are shown on the following table.

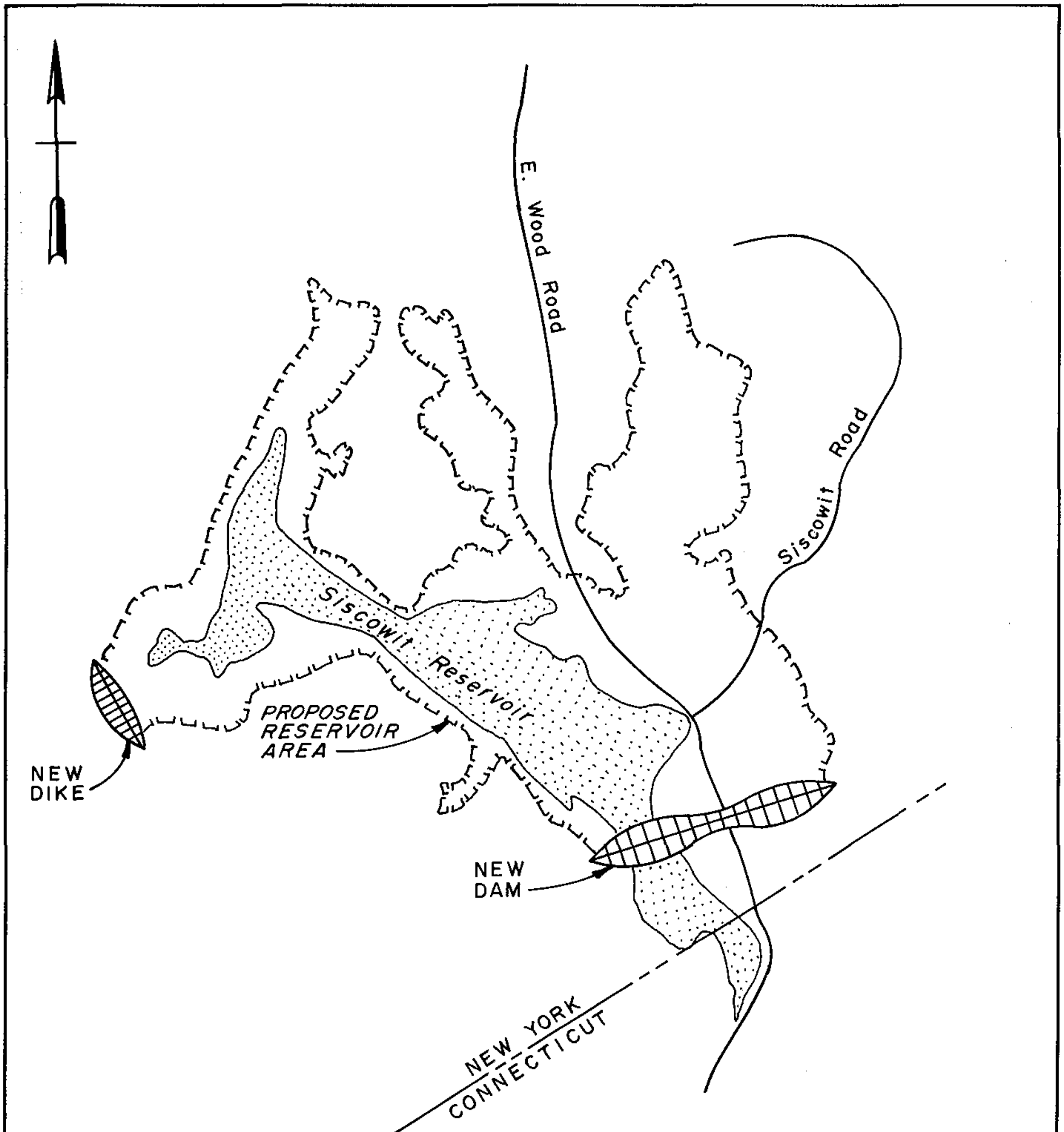
	Total Cost	Safe Yield	Cost per mgd
Shepaug Diversion	$19,860,000	4.5	$4,413,000
Raising Siscowit Reservoir	9,600,000	2.0	4,800,000
West Aspetuck Diversion	9,650,000	1.0	9,650,000
Bridgeport Hydraulic	1,450,000	2.0	725,000

Norwalk 2nd Taxing District

The Norwalk 2nd Taxing District water department presently serves about 5.1 mgd to approximately one-half of the population of Norwalk. The demand on the system is expected to increase to 5.8 million gallons a day by the year 2000 and up to 7.5 million gallons a day by 2030. The safe yield of their system is 4.5 million gallons a day and is obtained from 3 reservoirs. Norwalk 2nd also has a contract with Bridgeport Hydraulic Company to buy up to 3 million gallons a day on an as needed basis. If they were to maintain this contract throughout the long-term to the year 2030 they would not require any additional sources to be added to their system. However, Norwalk 2nd is selling approximately 1 mgd to the Noroton Water Co. Preliminary indications are that the amount of water sold to the Noroton Water Co. will increase in the future.

One alternative source that has been investigated for the Norwalk 2nd Taxing District is the Comstock Brook Reservoir. This reservoir was initially identified by the Soil Conservation Service. Preliminary indications are that the reservoir would cost about $4 million and could add up to 1.1 million gallons a day to the safe yield of the Norwalk 2nd system. This would alleviate their deficits through the year 2000.

Roald Haestad, Inc., recently completed a study of two diversions for the Norwalk 2nd Taxing District. They evaluated the additional safe yield that could be obtained from diversions of the Norwalk and Silvermine Rivers into the Norwalk 2nd Reservoir System. The Norwalk River diversion would include construction of a pumping station at Dana Pond and a pipeline into City Lake. Depending on the size of the pump station and the pumping rate, the safe yield could be increased by as much as 3.1 mgd.



HOUSATONIC RIVER BASIN
URBAN STUDY

SISCOWIT RESERVOIR

NOT TO SCALE

PLATE 8

The Silvermine River diversion would include construction of a pump station on the river at Borglum Road and a pipeline into City Lake. The additional safe yield available with this alternative is up to 1.6 mgd, but can be less depending on the pumping rate. Preliminary indications are that the Silvermine River diversion would cost about $1 million and the Norwalk River diversion approximately $500,000. The cost for the Norwalk River diversion does not include the removal of any discharges.

One major problem that arises with the use of the Norwalk River is its water quality. The river is presently designated as Class "B" by the State. Existing policies by the State require that for any river to be used as a water supply source it must have a Class "AA" or Class "A" designation. With the number of discharges into the Norwalk River, it is doubtful that it could ever be brought up to Class "A" standards. The following list summarizes the options studied for the Norwalk 2nd Taxing District, as delineated on Plate 9.

	Total Cost	Safe Yield	Cost per mgd
Comstock Brook Dam	$ 2,900,000	1.1	$2,636,000
Shepaug Diversion	13,750,000	3.0	4,580,000
Bridgeport Hydraulic*	0	3.0	0
Silvermine River Diversion	1,000,000	1.6	625,000
Norwalk River Diversion	500,000	3.1	161,000

*The cost identified is for construction of new facilities which are not needed in this case. Norwalk 2nd only has to pay for finished water from Bridgeport Hydraulic.

The Noroton Water Co. in Darien, the Norwalk 1st Taxing District and the New Canaan Water Co. are not discussed in detail here. Whereas they do not have any feasible future water supply sources available, they are discussed in detail in the following section on interconnections.

There are six other water companies identified in Table 2, in the problem identification section, as having potential deficits in the year 2030. Whereas these deficits are very small, under 0.5 million gallons a day, and do not occur until 50 years in the future, alternatives have not been formulated.

Interconnections

Interconnections between the various water companies are very important to an overall water supply plan for a given area. They enable the water companies to assist each other during emergency situations, such as droughts. As a long-term alternative, interconnections allow the water systems involved to utilize the exisitng developed sources to their maximum potential rather than developing new sources. The interconnection options discussed in this section do not have designs and costs associated with them. To do that would require specific knowledge of each distribution system and the various capabilities of each to transfer or receive additional water. Due to the scope and level of detail of this study, it was not feasible to obtain that type of data.

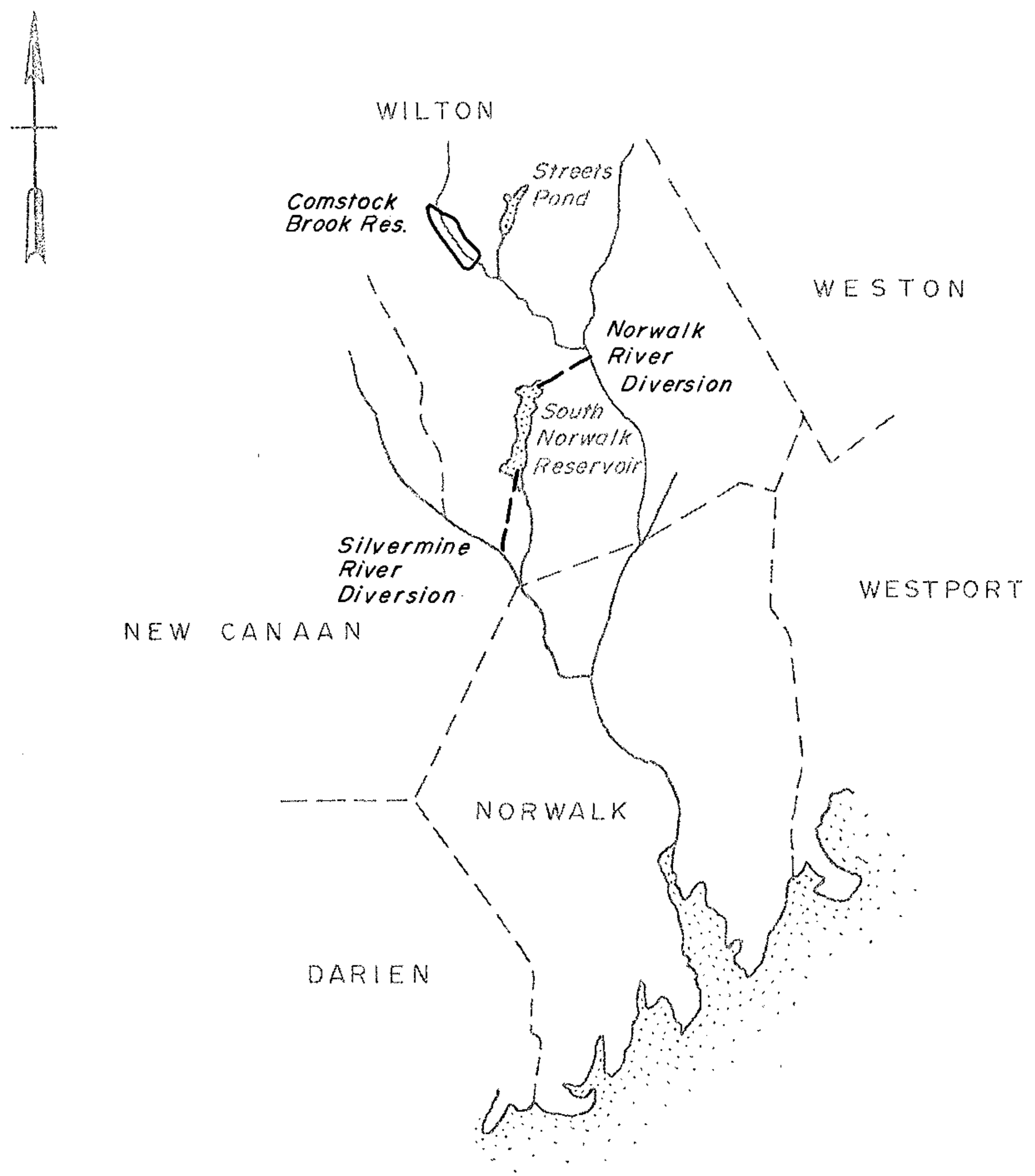
A map of existing interconnections between the various water companies is shown on Plate 10. The Greenwich District and the Stamford Water Company are presently interconnected at two places, each capable of transporting approximately 1 mgd. The first is between Stamford's Laurel Reservoir distribution system and Greenwich's Bargh Reservoir. The water received from the Stamford Water Company at this point is treated and drinkable but is fed directly into the Bargh or the Rockwood Lake Reservoirs and is susequently treated again before distribution. At this interconnection the water can only flow in one direction, from Stamford to Greenwich. The second interconnection is also capable of supplying up to 1 mgd. The water at this interconnection is only capable of flowing in one direction from Greenwich to Stamford. It would be advantageous to both water companies to increase the transfer capacity at each of these interconnection points.

Stamford is also connected with the Noroton District of the Connecticut American Water Company in Darien. There are four connections between the Stamford and the Noroton systems capable of supplying 2.5 mgd in either direction. The Noroton District presently serves the entire Population of Darien. The present demand on the system is 2.1 mgd and is expected to increase to 2.5 gd by the year 2000 and up to 3.1 mgd by the year 2030. Their present supply is obtained from the Stamford Water Company and the Norwalk 2nd Taxing District, about 1 mgd from each.

The opposite end of the Noroton System is interconnected with the Norwalk 2nd Taxing District through a 12 inch force main capable of supplying up to 1.4 mgd. Major modifications should be made to the pumping equipment and pipelines at this point. The transfer capability should be increased to at least 3 mgd. That would enable the Noroton District to obtain its entire supply from either Stamford or Norwalk 2nd, depending on where surpluses or deficits existed at any given time.

The New Canaan Water Company serves about 10,000 people, in New Canaan, an average of 1.06 million gallons of water a day. The average day demand is expected to increase to 1.35 mgd by the year 2000 and to 1.65 mgd by the year 2030. The present water supply system has a safe yield of 1.37 mgd which indicates they will require an additional 0.28 mgd supply source by the year 2030.

The New Canaan Water Company is presently interconnected with the Norwalk 1st Taxing District reservoir system and is able to draw up to 1 mgd of untreated water from the system when it is full. Part of the problem with the New Canaan system is the limited capacity of the treatment facilities. Therefore, their options for the future include either increasing the capacity of their treatment plant or interconnecting with Stamford or Norwalk 1st and buying treated water from them.



HOUSATONIC RIVER BASIN
URBAN STUDY

NORWALK 2nd TAXING DISTRICT ALTERNATIVES

NOT TO SCALE

PLATE 9

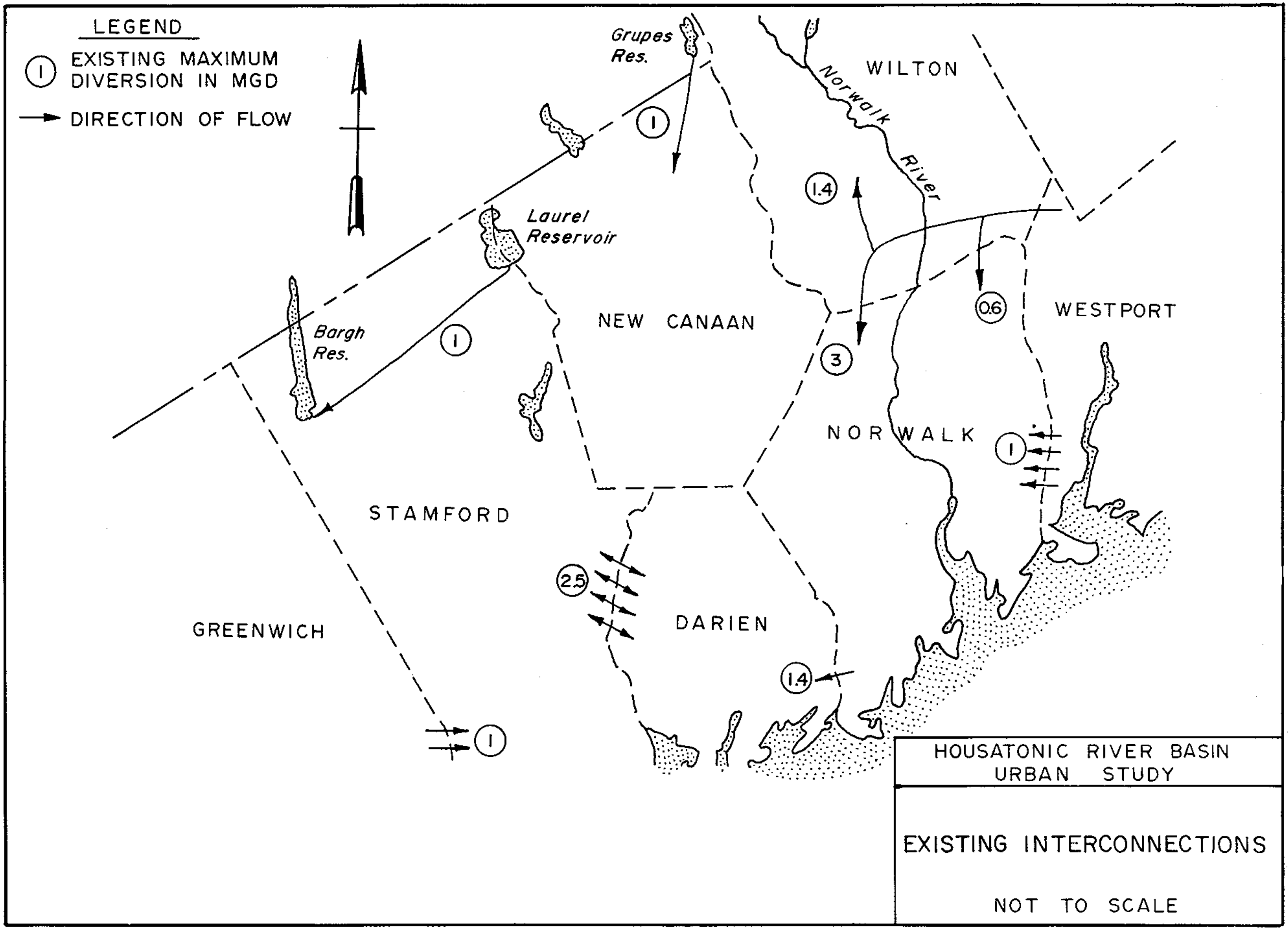

LEGEND
1 EXISTING MAXIMUM DIVERSION IN MGD
DIRECTION OF FLOW
Grupes Res.
WILTON
Norwalk River
Laurel Reservoir
Bargh Res.
NEW CANAAN
WESTPORT
NORWALK
STAMFORD
DARIEN
GREENWICH
1
1.4
0.6
3
1
1
2.5
1.4
1
HOUSATONIC RIVER BASIN URBAN STUDY
EXISTING INTERCONNECTIONS
NOT TO SCALE

PLATE 10

The Norwalk 1st Taxing District supplies water to about 42,000 residents in the city not served by the Norwalk 2nd Taxing District. The 1st District obtains its supply from both surface water and wells, with a combined safe yield of 6 mgd. The water department presently serves about 5.9mgd to its customers. The average day demand for the system is expected to increase to 6.9 mgd by the year 2000 and to 8.8 mgd by the year 2030.

There are presently two separate interconnections between Norwalk 1st and the BHC capable of supplying a total of 1.7 mgd. This capacity could be increased to supply the 2030 deficit of 2.8 mgd through minor modifications to the BHC system. The Norwalk 1st District also has the potential to interconnect with the Norwalk 2nd District, whereas, they both have major water mains running side-by-side along Silvermine Avenue for over a mile. This interconnection could benefit both water districts.

Massachusetts

In the Massachusetts portion of the Housatonic River Basin, there are nine water companies projected to have a need for additional water by the year 2030, as shown in Table 2 of the problem identification section. The Lee Water Department, the Lenox Water Department and the Pittsfield Water Department will be discussed in detail in this section. The other six water companies are projected to have very small long-term deficits, under 0.2 mgd, and therefore have not been studied in detail at this time.

Lee Water Department

The Lee Water Department is the sole supplier of water to the town of Lee, and serves approximately 95 percent of the 6,200 people in the town. The present average day demand on the system is 1.42 mgd, which is expected to increase to 1.6 mgd by the year 2000 and over 1.9 mgd by 2030. The total safe yield of the system is 849,000 gallons per day. The service area of the distribution system also includes a small portion of Lenox known as Lenox Dale.

Water supply alternatives have been studied in detail for the town by their consulting firm of Tighe and Bond, Inc. The following is a summary of these alternatives (see Plate 11) incorporated into the 1981 "Washington Mountain Brook Watershed, EIS" by the SCS. The costs have been generated by the consultant.

Two aquifer sites were investigated as potential future supplies, the Woods Pond aquifer and the Greenwater Brook aquifer. The Woods Pond aquifer is located just south of Woods Pond in Lenox. The plan assumes development of a 1.7 mgd wellfield and 10,000 feet of pipeline. The source is presently not acceptable by the State due to the presence of PCBs found in existing wells. The total cost to develop this source and treat the PCBs, for use by the town of Lee is $5,360,000.

The possibility of Woods Pond supplying an additional 0.75 mgd to the town of Lenox was also evaluated. Along with additional pumping capacity, 2,000 feet of piping would be required. The total initial cost to provide water to both communities would be $8,480,000. This plan assumes that the Woods Ponds aquifer is capable of yielding 2.45 mgd.

The Greenwater Brook aquifer is located in the town of Lee along Greenwater Brook, which is a tributary to the Housatonic River. This plan involves development of a 1.7 mgd wellfield and construction of 28,000 feet of pipeline to deliver the water to Lee. The total construction cost of this alternative would be $4,690,000.

This aquifer was also evaluated as a potential source for both Lee and Lenox. To supply an additional 0.75 mgd to Lenox would require the additional construction of a 4,000 foot long pipeline. To supply Lee and Lenox with the required 2.45 mgd would cost approximately $6,830,000.

The alternative includes construction of the Schoolhouse Lake and October Mountain Lake sites for water supply purposes. Development of both sites would provide a combined safe yield of 1.7 mgd. The total construction cost of this project would be $5,530,000 and would provide for the needs of Lee.

To increase the yield of the reservoirs to 2.45 mgd to provide for the needs of Lenox was also investigated. This plan would require an additional 10,000 feet of pipe. The total cost to supply the future demands of Lee and Lenox would be $8,000,000.

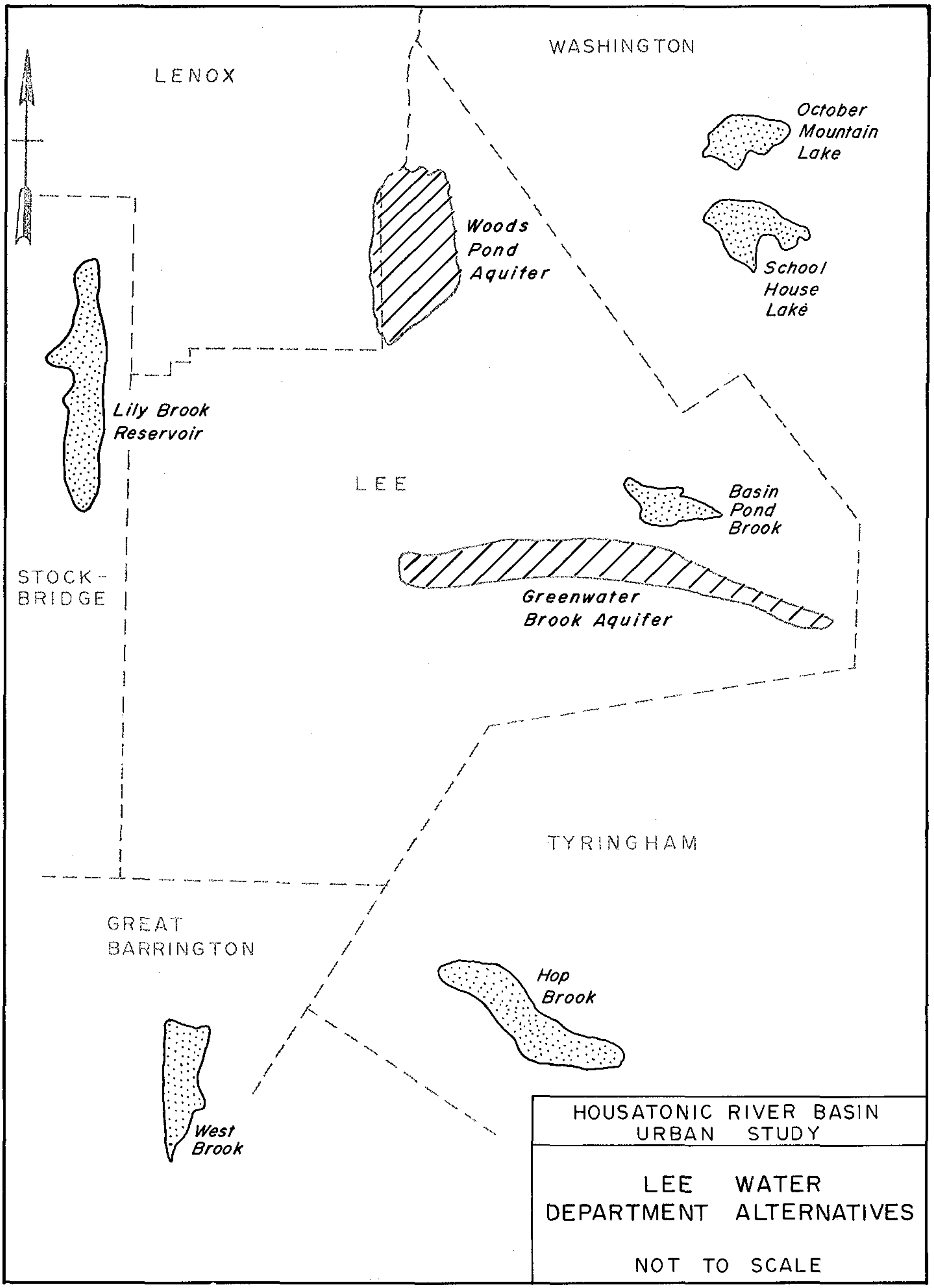
The Lily Brook reservoir if constructed would be located east of Stockbridge Bowl in Stockbridge, Massachusetts. In addition to the dam, 1800 feet of pipeline would be required to supply 1.7 mgd to the town of Lee. The total cost of this alternative is estimated to be $5,760,000.

If the above plan were to be expanded to supply Lenox an additional 4000 feet of pipeline would be required. The cost to serve both communities a total of 2.45 mgd would be $7,940,000.

Another surface water alternative site investigated is Basin Pond Brook in Lee. The total cost of this plan, to provide water to Lee, is $7,340,000 and includes construction of the dam and 1800 feet of pipeline.

In order to serve 0.75 mgd to the town of Lenox an additional 4000 feet of pipeline would be required. The cost to supply both Lee and Lenox would be $9,520,000.

The next surface water plan includes the development of Hop Brook in Tyringham, Massachusetts. The construction required to develop this site includes the dam and 18,000 feet of pipeline. The total construction cost



HOUSATONIC RIVER BASIN URBAN STUDY

LEE WATER DEPARTMENT ALTERNATIVES

NOT TO SCALE

PLATE 11

to provide the 1.7 mgd to Lee would be about $7,680,000. To add Lenox to this plan would increase the total cost to $9,860,000 and include an additional 4000 feet of pipeline.

The last surface water site investigated is on West Brook in Great Barrington, Massachusetts. In order to provide the required 1.7 mgd to Lee, a dam and 30,000 feet of pipeline would be required at a total cost of $7,880,000. To increase the capacity of this system to 2.45 mgd and serve Lenox, an additional 4000 feet of pipeline would be needed. The total cost of the plan would then be $10,050,000.

The Lee Water Department has been participating in an ongoing water conservation program. An important portion of their operation and maintenance includes leak detection and repair efforts. The water department has also studied, in detail, the feasibility of installing meters throughout the service area. The meters have not proven to be cost effective to date and therefore, have not been installed. Pressure reducing valves are used extensively throughout the Lee water distribution system. The valves have been successful in reducing the pressures in some areas from 120 psi to 60 psi. This is significant in reducing the amount of water lost through leaks.

The water department has an emergency interconnection with Goose Pond and plans to interconnect with Laurel Lake in the near future. Lee has an ongoing public education program through the Tri-Town Rotary Club and school system.

Table 5 lists the alternatives investigated for the Lee Water Department and the Lee - Lenox Departments.

Lenox Water Department

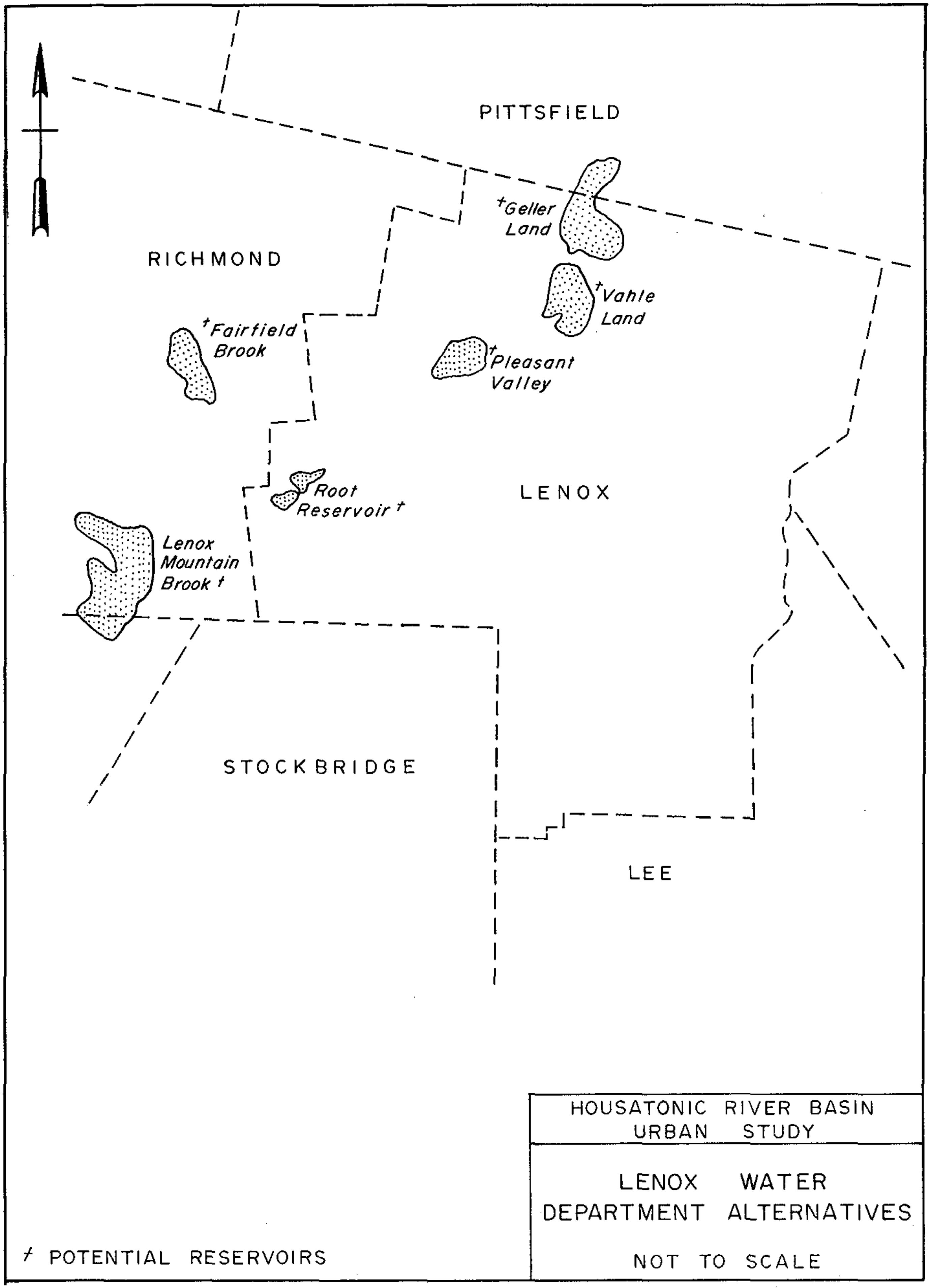
The Lenox Water Department presently serves about 80 percent of the population of Lenox. The existing average day demand on the system is approximately 1.0 million gallons per day. This demand is expected to increase to 1.2 mgd by the year 2000 and 1.4 mgd by the year 2030. The safe yield of the existing system is 0.6 mgd, which is obtained from the Upper and Lower Root Reservoirs. The northeast section of Lenox is presently served by the Pittsfield Water Department and the Lenox Dale section by the Lee Water Department.

Ten alternative water supply plans (see Plate 12) were evaluated in detail by Whitman and Howard, Inc. and discussed in the 1981 SCS report "Washington Mountain Brook Watershed, EIS". The following is a brief description of the plans identified in that report.

TABLE 5

LEE WATER SUPPLY PLANS

	Lee Development		Lee-Lenox Development	
	Total Cost	Cost Per MGD	Total Cost	Cost Per MGD
Woods Pond Aquifer	$5,360,000	$3,152,200	$8,480,000	$3,462,900
Greenwater Brook Aquifer	4,690,000	2,760,500	6,830,000	2,788,900
Washington Mtn. Brook Project	5,530,000	3,251,000	8,000,000	3,266,100
Lily Brook Reservoir	5,760,000	3,388,200	7,940,000	3,239,300
Basin Pond Brook Reservoir	7,340,000	4,319,100	9,520,000	3,885,200
Hop Brook Reservoir	7,680,000	4,519,800	9,860,000	4,024,400
West Brook Reservoir	7,880,000	4,633,900	10,050,000	4,103,600



† POTENTIAL RESERVOIRS

HOUSATONIC RIVER BASIN
URBAN STUDY

LENOX WATER
DEPARTMENT ALTERNATIVES

NOT TO SCALE

PLATE 12

The Pleasant Valley reservoir plan consists of a dam and reservoir on Yukon Brook which would flood 55 acres of Massachusetts Audubon Society land. The reservoir would increase the safe yield of the system by 1.0 mgd. A 2.0 mgd treatment plant would be required along with 12,300 feet of pipeline. The total cost of this plan would be $4,670,000.

The Geller Land site involves the construction of a dam and reservoir with a surface area of 110 acres. The plan involves the pumping of Yukon Brook into the impoundment to develop a 1.0 mgd yield. This plan would also require construction of a 2.0 mgd treatment plant and 15,500 feet of pipeline. The project would require 30 acres of land in Lenox and 83 acres of land in Pittsfield. The total cost of this project is $5,080,000.

The Vahle Land site includes the construction of a dam and reservoir along Yukon Brook in Lenox. The project would increase the safe yield of the Lenox Water System to 2.26 mgd. A 15,500 foot long pipeline and a 2.0 mgd treatment plant would be required. The reservoir would flood three homes along Mountain Road. The total cost to construct this reservoir would be $4,450,000.

This plan involves the pumping of Yukon Brook into a dam constructed adjacent to Reservoir Road in Lenox. Two pump stations and 9000 feet of pipeline would be required for the diversion and an additional 12,000 feet of pipeline to deliver the water. This project would require the purchase of 23 acres of land and provide about a 1.0 mgd safe yield. The total cost of this site is $8,580,000.

The Fairfield Brook site involves the construction of a dam and reservoir in the town of Richmond. The reservoir would inundate an area of 115 acres and flood three homes along Fairfield Brook. The safe yield provided by this project would be 0.74 mgd. Construction of a 2 mgd treatment plant and 23,000 feet of pipeline would also be required. The total cost of this plan would be $4,699,000.

The Lenox Mountain Brook reservoir includes a dam in the town of Richmond on Lenox Mountain Brook, downstream of the Root Reservoirs. The safe yield available from this plan would be only 0.32 mgd, and therefore not considered feasible.

The feasibility of raising the Lower and the Upper Root Reservoirs was investigated. Raising the Lower Root Reservoir could increase the safe yield of the system by 0.4 mgd and would cost approximately $5,920,000. The possibility of raising the Upper Root Reservoir is essentially the same as the lower. The safe yield would only be increased by 0.4 mgd at a cost of $4,820,000. Only one or the other of these two reservoirs could be raised. No additional safe yield could be obtained by raising both, due to the size of the watershed area.

This alternative includes the construction of deep rock wells at the base of October Mountain in New Lenox. The plan assumes the wellfield will provide a one mgd safe yield. A one mgd lime-soda ash water softening treatment plant, 22,400 feet of pipeline and a pump station will be required. The total cost of this plan will be $3,300,000.

The Foess well alternative consists of drilling a deep rock well along the Housatonic River in Lee. It is anticipated that the water would be hard and need lime-soda ash softening. The total cost to construct the wellfield, 15,000 feet of pipeline, a treatment plant and pump station would be $2,510,000. The safe yield from this plan is estimated to be about 1.0 mgd.

The last plan studied would involve buying 0.5 mgd from the Schweitzer Paper Company. This plan would have required a pump station and 15,000 feet of pipe. But due to the discovery of PCBs (polychlorinated biphenyls) in the Schweitzer wells, the Massachusetts Department of Environmental Quality Engineering has ruled out their use as a municipal water supply.

The town of Lenox is actively practicing water conservation. For example, they have recently voted into law that water saving fixtures must be used on all new plumbing or repairs done to existing plumbing. They are also 100 percent metered. The Berkshire County Regional Planning Commission and the Tri-Town Rotary have sent out letters listing methods to conserve water. Lenox also has a successful leak detection and repair program.

Table 6 lists the alternative plans investigated for the Lenox Water Department.

TABLE 6

Lenox Water Department

	Total Cost*	Safe Yield	Cost per mgd
Pleasant Valley Reservoir	$4,670,000	1.0	$4,670,000
Geller Land Reservoir	5,080,000	1.0	5,080,000
Vahle Land Reservoir	4,450,000	1.66	2,680,000
Reservoir Road	8,580,000	1.0	8,580,000
Fairfield Brook Reservoir	4,700,000	0.74	6,350,000
Raising Upper Root Reservoir	4,820,000	0.4	12,055,000
Rock Wells	3,300,000	1.0	3,300,000
Foess Well	2,510,000	1.0	2,510,000
Washington Mountain Brook	2,475,000	0.75	3,300,000

* Does not include the cost of land.

Pittsfield Water Department

The Pittsfield Water Department presently serves all of Pittsfield and a portion of Dalton and Lenox. The existing demand on the system is about 15 mgd. The projected demand for the year 2030 is expected to increase to approximately 19 mgd.

The safe yield of the existing system is 14.7 mgd and is obtained from three reservoir systems, the Cleveland Brook System, Ashley System and Millbrook System.

Many alternative sources for future use by Pittsfield have been evaluated in the past. One of the major surface water sources identified is the Windsor Project. The project consists of a large reservoir and dam in the town of Windsor in the upper reaches of Windsor Brook. The proposed reservoir would store spring freshets presently not captured by the existing Windsor Reservoir owned by the Dalton Fire District. A small dam and pump station would also be constructed on Westfield Brook to collect excess flows and divert them to the Windsor impoundment. The water would then be diverted to the Cleveland Reservoir for use by Pittsfield. An additional pipeline from Cleveland Reservoir to Pittsfield would also be required to carry the additional supply. The total safe yield of this project is 4.0 mgd. The cost of the project is estimated to be $12.5 million.

Groundwater sources for Pittsfield were studied in 1981 by a consultant, Ward S. Motts and reported in "The Potentiality of Groundwater as a Water Supply Alternative for Pittsfield, Massachusetts". In the report there are three sites identified as potentially favorable for deep rock wells. The sites are (1) along the Pine Mountain Thrust Fault in

West Pittsfield, (2) along a prominent bedrock fault in Unkamet Brook and (3) in the Brattle Brook area near the bedrock hills in East Pittsfield. Indications are that properly constructed wells in these areas could yield well over 1 mgd. Test drilling has been recommended to determine the actual yield available and the feasibility of developing them as water supply sources.

The report also studied potential groundwater in the stratified drift (sand and gravel) deposits. The Secum Brook, Daniels Brook, Unkamet Brook and Vincent Farm - Brattle Brook aquifers were found to have the highest potential for development.

The Secum Brook aquifer is located in the southern part of Lanesborough. It is estimated to have a safe yield of about 1.5 mgd. Development of this aquifer would include a wellfield, pump station, treatment plant and 24,000 feet of pipeline. The total cost to construct these facilities would be $2,200,000. There is a potential for groundwater quality problems in the Secum Brook watershed. In the southern part of the basin is a former industrial landfill which contains hazardous wastes. Upstream of the aquifer is the existing Lanesborough landfill.

The Daniels Brook aquifer is located upstream from Onota Lake in the northwestern part of Pittsfield. The aquifer is estimated to have a safe yield of just over 1.0 mgd. Construction of a wellfield, pump station, treatment plant and 13,600 feet of pipeline would be required. The total cost to develop this site is estimated to be $1.6 million. There are no known quality problems in this watershed.

The third favorable site is located along Unkamet Brook in the northeastern portion of Pittsfield. The estimated safe yield of this aquifer is 1.2 mgd. This plan would include the construction of a wellfield, pump station, treatment plant and 12,000 feet of pipeline. The cost of this alternative is estimated to be approximately $1.6 million. There do not appear to be any quality problems due to the fact that the wellfield can be located far enough upstream from the East Branch Housatonic River.

The last and largest site investigated is the Vincent Farm - Brattle Brook aquifer. The site is located in the eastern portion of Pittsfield along Brattle Brook. The sediments consist of an upper aquifer separated from a lower aquifer by a confining layer of silts and clays. It has been estimated that the aquifer could yield from 4-8 mgd. Normal groundwater flow is from the lower aquifer to the upper aquifer to the East Branch Housatonic River. If wells were put in and heavily pumped, the flow could reverse itself and flow toward the wells. This would present the possibility of contamination.

Two sources of contamination could affect this aquifer. PCB's could be drawn into the wells from the East Branch Housatonic River or possible toxic contaminants from existing and abandoned landfills. The severity of contamination from induced filtration is probably related to the amount of water pumped from the aquifers. It is likely that up to 2.0 mgd can be withdrawn from the aquifer with no serious quality degradation.

Much higher amounts of water can be withdrawn from the aquifer if measures were taken to protect the water quality of the wells. Two such measures are a trench around the abandoned landfill to act as a groundwater barrier, or an artificial recharge trench between the source of contamination and the wells.

The total cost to develop this aquifer to yield 2.0 mgd has been evaluated. The plan involves a wellfield, pump station, treatment plant and 10,800 feet of pipeline. The cost of this alternative is $2.7 million.

The following table lists the alternatives studied for the Pittsfield Water Department and are shown on Plate 13.

Pittsfield Water Department

	Total Cost	Safe Yield	Cost per mgd
Windsor Project	$12,500,000	4.0 mgd	$3,125,000
Secum Brook Aquifer	2,200,000	1.5 mgd	1,470,000
Daniels Brook Aquifer	1,600,000	1.0 mgd	1,600,000
Unkamet Brook Aquifer	1,600,000	1.2 mgd	1,330,000
Vincent Farm-Brattle Brook Aquifer	2,700,000	2.0 mgd	1,350,000

FLOOD DAMAGE REDUCTION

Potential Management Measures

Intense runoff is the natural consequence of severe rainfall or a combination of rainfall and snowmelt in any river basin. The volume and intensity of rainfall and the rate of snowmelt are beyond human control. Thus runoff will always occur, and mankind can only attempt to control the timing of the runoff from the natural phenomena. Over the years various means to control or avoid damages from flooding have been developed. New ideas or variations on old ideas have evolved as society has developed and the uses of land within the natural flood plain have changed. Today there is a wide spectrum of alternatives available for consideration when developing a flood damage reduction plan for a particular locale. This section of the report attempts to review the complete set of available measures. To aid in the review process it is useful to categorize the alternatives to indicate the relationships between the various strategies. This section is intended to provide a review of the full set of options prior to screening them to fit the problem areas under discussion.

The following (Table 7) identifies the alternative measures evaluated for this project.

Table 7
POTENTIAL FLOOD MANAGEMENT MEASURES

Decrease Flooding
1. Adjust Runoff Rate
2. Reservoirs
3. Natural Valley Storage
4. Divert Flows
5. Increase Channel Capacity
6. Removal of Dams
7. Bridge Modification
8. Dikes

Decrease Impact of Flooding
1. Flood Proofing
    a. Rearranging Property Within Existing Structure
    b. Closures
    c. Small Walls or Dikes
    d. Raising Structure
    e. Relocation
2. Flood Warning and Evacuation
3. Flood Plain Regulation
4. Flood Insurance
5. Public Acquisition of Flood Plain Land

Decrease Flooding

Adjust Runoff Rate. The practices designed to adjust the runoff rate are generally inexpensive, and often have beneficial side effects. For example, farming practices such as contour plowing and crop rotation generally improve crop yields as well as decrease runoff rates. However, such measures generally have only a limited effect on peak runoff rates, and are normally used in conjunction with other measures. In addition, the runoff control measures must be undertaken by upstream residents who often do not directly benefit from their implementation.

Reservoirs. Reservoirs can be used to impound water during storms for release after the threat of flooding subsides. To be used for this purpose, the reservoir must have storage specifically allocated for flood control -- storage which is unused when the flood begins but which can be used to store water temporarily. New reservoirs can be built for this purpose, and existing non-flood control reservoirs can sometimes be converted from other uses to flood control. Reservoirs have traditionally been one of the primary methods of flood control.

The usefulness of reservoirs depends on the characteristics of the area. If a suitable site is available, a reservoir can cut peak flows by

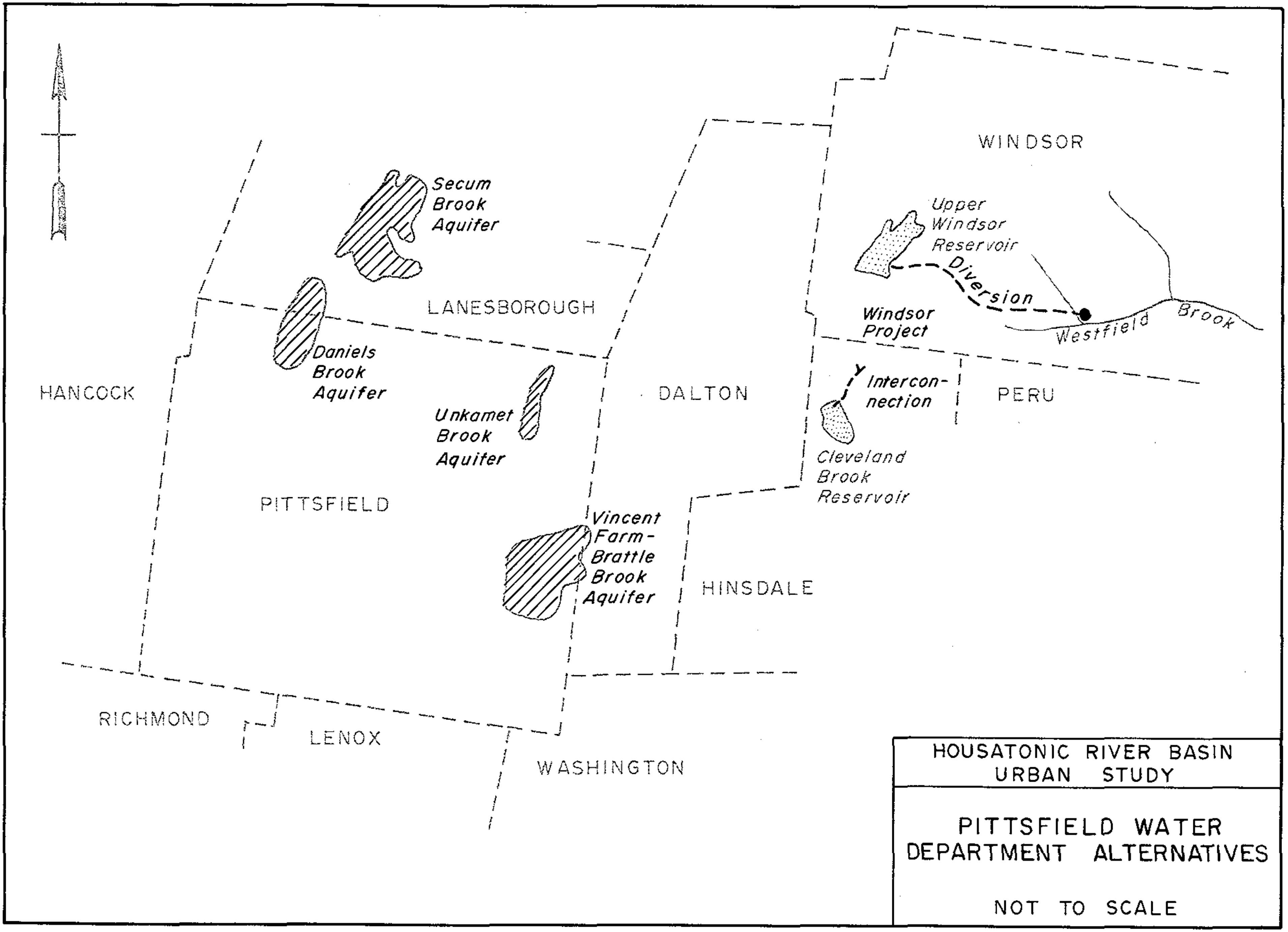

WINDSOR
Secum Brook Aquifer
Upper Windsor Reservoir
Diversion
Windsor Project
Westfield Brook
LANESBOROUGH
Daniels Brook Aquifer
HANCOCK
DALTON
PERU
Interconnection
Unkamet Brook Aquifer
Cleveland Brook Reservoir
PITTSFIELD
Vincent Farm-Brattle Brook Aquifer
HINSDALE
RICHMOND
LENOX
WASHINGTON
HOUSATONIC RIVER BASIN URBAN STUDY
PITTSFIELD WATER DEPARTMENT ALTERNATIVES
NOT TO SCALE

PLATE 13

a large amount, and thus open much of the flood plain downstream for development. Reservoirs can also offer additional benefits such as recreation and water supply storage.

The disadvantages of reservoirs include the loss of the otherwise useful land flooded by the impoundment. Valuable ecological areas or useful farm or forest land may be lost in the flood pool behind a dam. Also, the existence of an upstream reservoir or reservoirs can cause "over-confidence" and "overuse" of the flood plain downstream, beyond the protection actually provided. In most cases, dams do not eliminate flooding, they only reduce the peak flow from the level that would have occurred if the dam did not exist.

Natural Valley Storage. Natural storage such as that provided by wetlands or flood plains can serve the same purpose as a reservoir. Such areas can hold a significant volume of water until downstream flooding has subsided. Such storage can be maintained by protecting these areas from encroachment and development. Wetland storage can be increased by artificially limiting outflow during storms.

Divert Flows. Another way to decrease flood flows at critical areas is to divert all or part of such flows around the potential damage site. Flows can be diverted to other natural channels, man-made channels, or conduits. This measure can be useful in some cases, but has definite drawbacks. Diversion to another natural channel results in increased flow -- and perhaps increased flooding -- on that stream. Man-made channels are expensive and potentially unsightly, while closed conduits are even more expensive. Generally, this approach works best when a relatively short diversion avoids the area of concern.

Increase Channel Capacity. Another approach is designed to increase the capacity of the channel at the area of concern. The measures will be less effective if the stage is affected by backwater from a downstream control. It is worth noting that channel improvements may actually increase flooding downstream of the area of concern. By decreasing the upstream stage the improvements decrease flood plain storage, thus reducing the impact that the valley storage has on the timing of the runoff from the area.

The object of this approach is to reduce "drag" on the water, thus allowing it to flow faster at a given stage. This can be accomplished by clearing the channel of vegetation, snags, and other natural obstructions to flow. Channel clearing and maintenance programs are often a part of flood damage mitigation plans. However, alone they usually achieve only minor reductions in stage.

Another method of reducing channel friction is to line the channel with a relatively smooth covering, such as concrete. This is generally more expensive, but also more effective than channel clearing. However, as a drawback, such lining is frequently aesthetically unpleasing.

Removal of Dams and Bridge Modification. Obstructions such as bridges, dams, culverts, or other encroachments (buildings, etc.) often affect the water surface upstream for a given distance. It may be desirable to modify the structures to alleviate the control at that point. Bridges and culverts can be enlarged; dams can have gates added or spillways expanded. In the case of older, unused structures, removal is often simpler and less expensive than modification.

If the cross sectional area of the channel is increased, it becomes more likely that a given flow can be contained within the channel banks and flood damages eliminated. Dredging the channel to deepen or widen it can accomplish this goal, at the cost of some harm to vegetation along the stream. Dredging is also expensive for major channel area increases.

Dikes. Another way to increase the channel cross section is to raise the channel walls with levees. This practice has the disadvantage that overtopping of the levees can result in sudden and catastrophic increase in flood levels behind them, for which flood plain occupants are often unprepared.

It is possible that obstructions downstream of the area of interest would create flooding by backing the water up at high flows. Such obstructions can be removed or modified to allow flood flows to pass freely.

Decrease Impact of Flooding

Decreasing the impact of flooding is primarily considered non-structural flood control.

Flood Proofing Measures. Flood proofing measures can be classified into three broad categories. First are permanent measures which become an integral part of the structure or land surrounding it. Second are temporary or standby measures that are used only during floods, but are constructed and made ready prior to any flood threat. Third are emergency measures that are carried out during flood situations in accordance with a predetermined plan.

The rearrangement or raising in place of contents within a structure is easily accomplished and can result in significant savings should a flood occur. Utility cells and rooms, while effective flood proofing measures, are expensive and require professional expertise. Because of the expense involved, utility cells and rooms are applicable only to those property owners who experience high flood damages.

The degree to which property can be rearranged and protected is site specific. It depends on the flood hazard, principally depth and frequency of flooding, and the damageable property and its type, value, location and mobility. Shallow flooding allows the use of protective types of measures where appliances, utilities, equipment, and goods can be raised in place, surrounded, or enclosed and protected. Where the hazard is more severe and inundation is to greater depths, property would need to be relocated to prevent damage.

Structures whose exterior is relatively impermeable to water can be designed to keep floodwaters out by installing watertight closures to openings such as doorways and windows. Due to the hydrostatic and buoyant pressures floodwaters exert on the building's walls and basement, this method is better suited for commercial and industrial structures that are more structurally sound. While some seepage will probably always occur, it can be reduced by applying sealants to walls and floors and providing floor drains where practical. Closures may be temporary or permanent. Temporary closures are installed only during a flood threat and need warning time before installation.

Walls and dikes are designed to protect one or several structures, and are built to be compatible with local landscape and aesthetics. Walls may be of various masonry materials designed to resist the lateral and uplift presures associated with flooding. Levees or dikes are usually constructed with an impervious inner core to prevent seepage and with slope protection where erosion is a problem. Where access openings are necessary, provisions must be made to close these openings during floods. This generally means providing a floodgate that can either be stored at the opening and installed when needed, or constructing it on hinges or rollers for automatic or semiautomatic closure.

During flood conditions it is possible for precipitation, seepage and runoff from roof drainage to cause water to accumulate inside a wall or dike and cause water damage to the property being protected. This problem can be reduced by providing interior drainage facilities to remove the water. Generally, this includes construction of a low-lying sump area to collect the drainage and a pump to remove it. As part of the interior drainage facilities, backup can be prevented by installation of appropriate valves in discharge lines.

Raising an existing structure involves raising the structure above expected flood levels. The building is raised on jacks by a professional mover and a new foundation is built and/or the lot is regraded to provide higher ground under the structure. The flood proofing method is not complete unless the building is evacuated during the early stages of a flood. Otherwise, people may become trapped inside and be in extreme danger should a catastrophic flood occur.

There are basically two options for removing property to a location outside the flood hazard area. One is to remove both structure and contents to a flood free site, and the second is to remove only the contents to a different structure located outside the flood hazard area and demolish or reuse the structure at the existing site within the flood plain. In each case the purpose is to remove damageable property from the hazard area, yet take advantage of opportunities for using the existing property in ways that are compatible with the hazard.

Relocation of a house that is subject to frequent flooding involves the physical raising and moving of the superstructure to a new site beyond the limits of the flood plain. This entails disconnecting and capping all utilities at the present site, removal of obstructions enroute to the new location, construction of a new foundation/basement at the relocation site, backfilling the existing basement, and landscaping both lots.

Flood Warning and Evacuation. Flood forecasts, warning and evacuation is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.
- Procedures for issuance and dissemination of a flood warning.
- Arrangements for temporary evacuation of people and property.
- Provisions for installation of temporary protective measures.
- A means to maintain vital services.
- A plan for postflood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process can communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday, weekend) and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain credibility of future warnings.

An effective warning needs to be followed by an effective response. This means prompt and orderly evacuation of people and property. Actions that can facilitate this include:

- Establishment of rescue, medical and fire squads.
- Identification of rescue and emergency equipment.
- Identification of priorities for evacuation.
- Surveillance of evacuation to insure safety and protect property.

Flood Plain Regulations. Through proper land use regulation, flood plains can be managed to insure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including: zoning ordinances, subdivision regulations, and building and housing codes. Their purpose is to reduce flood losses by controlling the future and existing use of flood plain lands.

Zoning regulates the use of structures and land, the height and bulk of structures, and the size of lots and density of use. It is usually based upon some broad land use plans to guide the growth of the community. Subdivision regulations guide the division of large parcels of land into smaller lots for the purpose of sale for building development. Subdivision regulations with special reference to flood hazards often (1) require installation of adequate drainage facilities, (2) require filling of a portion of each lot to provide a safe building site at elevation above selected flood heights, and (3) require the placement of streets and public utilities above a selected flood protection elevation. Building and Housing Codes neither regulate where development takes place nor the type of development, but rather specify building design and materials.

Adoption, administration, and enforcement are essential steps for successful flood plain regulation programs.

Flood Insurance. Flood insurance is not really a flood damage prevention measure as it does not reduce damages; rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners. Prior to this program, the response to flood disaster was limited to the building of flood control works and providing disaster relief to flood victims. Insurance companies would not sell flood coverage to property owners, and new construction would often overlook new flood protection techniques. The insurance program, however, did not come about overnight; it took several attempts and 17 years before the bill was approved and put into effect.

Flood insurance is an option for all owners of existing buildings in a community identified as flood-prone, yet it is compulsory for all buyers of existing or new buildings in the Federal Emergency Management Agency (FEMA) designated 100-year flood plain where Federally insured mortgages or mortgages through Federally connected banks are involved.

Qualifying for the National Flood Insurance Program involves a community in two separate phases -- the Emergency phase and the Regular phase. The Emergency phase limits the amount of insurance available to local property owners. In this phase, FEMA provides the community with a Flood Hazard Boundary Map that outlines the flood-prone areas within the community. Owners of all structures, regardless of their flood risk, are charged subsidized rates during this phase of the program.

In order to qualify for the Emergency Program, a community must adopt preliminary flood plain management measures including building permits for all proposed construction or other development in the community, which must be reviewed to assure that sites are reasonably free from flooding. The community must also require that all structures in flood-prone areas be properly anchored and made of materials that will minimize flood damage, new subdivisions must have adequate drainage, and new or replacement utility systems must be located and designed to prevent flood loss.

The full amount of flood insurance is available under the Regular phase of the program. The amounts charged for insurance of new construction vary in accordance with the structures. Flood plain management efforts of the community become more comprehensive and new buildings must be elevated or flood proofed above certain flood levels. The flood proofing levels are shown on a Flood Insurance Rate Map which is derived from a detailed onsite engineering survey in the community. This map also shows flood elevations and outlines risk zones for insurance purposes.

When the Flood Insurance Rate Map is completed, the community may qualify for the Regular Program by adopting more comprehensive flood plain management measures. Along with the measures adopted for the Emergency program, the community must also require that all new construction or any substantial improvements to existing structures be elevated or flood proofed to the level of the base flood.

Public Acquisition of Flood Plain Land. Public control over the flood plain may be obtained by purchasing the title or some lesser rights such as development or public access rights. Acquisition of the title is better suited for undeveloped or sparsely developed land in the flood plain. It is a very desirable means, however, of protecting and/or providing public access for environmental, wildlife protection, public open space and recreation or other purposes.

Analysis of Plans Considered in Preliminary Planning

Flood damage reduction measures were evaluated using engineering judgement and brief study of the entire Housatonic River Basin. Each measure was judged on its own merits. Those not considered adequate, feasible, practical or realistic engineering solutions or those measures found socially or environmentally unacceptable or economically unjustified, were eliminated from further study.

The screening process gave consideration to both nonstructural and structural measures. Measures studied in detail include dams, dikes, diversions, channel improvements, flood proofing, flood warning and evacuation, flood plain regulations, flood insurance and acquisition. Damage throughout the basin is too scattered and does not occur frequently enough to justify structural solutions. Therefore those measures which passed the initial screening were primarily nonstructural in nature.

There are many economically feasible flood proofing opportunities throughout the basin. The analysis of flood proofing alternatives was divided into two distinct categories: residential and commercial-industrial. Flood proofing alternatives applicable to residences were evaluated on a benefit/cost ratio basis for the homes in study area. The aggregated results of this analysis are presented in Table 8.

Flood proofing alternatives applicable to commercial-industrial structures were evaluated differently. Specific benefit/cost ratios were not determined for each structure due to the amount of detailed data required for each structure to determine the cost of adequate protection. The results of this analysis are presented in Table 9.

TABLE 8

RESIDENTIAL STRUCTURES SUITABLE FOR FLOOD PROOFING

	# Structures Raising 100 yr	# Structures Raising 500 yr	Utility Rooms	Annual Benefits ($000's)	Annual Costs ($000's)	B/C
Pittsfield	20			92.22	39.72	2.32
Pittsfield		51		165.16	109.86	1.50
Pittsfield			3	1.84	2.01	.92
Lee		4		8.56	8.26	1.04
New Milford		2		6.66	5.54	1.20
Seymour - Oxford	9			26.23	19.05	1.38
Seymour - Oxford		5		39.74	11.64	3.41
GRAND TOTAL	29	61	3	340.41	196.03	1.77

TABLE 9

COMMERICAL/INDUSTRIAL FLOOD PROOFING CANDIDATES

Community	Closures	Walls or Earth Work	Total
Massachusetts			
Dalton	5	0	5
Pittsfield	30	4	34
Lee	2	7	9
Massachusetts Subtotal	36	12	48
Connecticut			
Kent	4	8	12
New Milford	-	7	7
Brookfield	5	7	12
Danbury	28	11	39
Seymour	-	6	6
Derby	2	-	2
Shelton	20	-	20
Watertown	2	4	6
Torrington	3	-	3
Connecticut Subtotal	64	43	107
GRAND TOTALS	100	55	155

The National Weather Service (NWS) was requested to examine the possibility of supplementing their existing flood warning system. Based on the flood problems identified in the course of our study, the NWS prepared estimates for and proposes 3 ALERT forecasts networks which would service principal flood damage areas in the basin. The networks (shown on Plate 14) would provide detailed flood forecasts for:

1. Dalton, Pittsfield, Lee and Great Barrington (see Table 10)
2. Kent and New Milford (see Table 11)
3. Danbury and Brookfield (see Table 12)

Analysis of Plans by Community

The 14 communities (shown on Plate 15) with the highest potential for flooding were investigated in detail. The applicability of each of the flood management measures was evaluated. The findings of this investigation for each community is presented below.

DALTON. This community has limited residential flood plain development, and none of the homes were found to be economically justified for flood proofing.

Several commercial-industrial properties appear suitable for non-structural flood damage reduction measures. The 40-unit elderly housing complex located adjacent to Center Pond is of brick construction and many of the units could be flood proofed by the use of closures. Based on preliminary estimates it appears 24 units could be protected with closures. A comparison of general costs compared to benefits indicate a high BCR (Benefit to Cost Ratio) could be achieved while providing 100-year protection.

At the four mills located downstream of Center Pond, detailed damages were not available but the construction of the plants suggest closures may be an effective measure.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. A more detailed plan described earlier if developed as part of the upper basin warning system would provide about 3 hours of lead time for property owners to implement flood proofing and evacuation activities.

Dalton is currently in the Emergency phase of the NFIP, but is expected to enter the Regular phase in the near future. At that time, the town will be required to enforce minimum NFIP flood plain regulations described earlier.

Four homeowners in Dalton have flood insurance policies totalling $112,500 and no commercial or industrial establishments currently have flood insurance. While it appears that residential use of flood insurance could be improved, lack of commercial and industrial coverage could lead to significant losses.

TABLE 10

ALTERT SYSTEM
BERKSHIRE COUNTY, MA

I. SENSOR NETWORK

		Estimated Cost
East Branch, Housatonic River		
1 precipitation gage, Windsor, MA		3,100
1 river/precipitation gage, Dalton, MA		3,900
	Subtotal	$ 7,000
West Branch, Housatonic River		
1 river/precipitation gage, Ponotoosuc Lake		3,900
1 river/precipitation gage, Onota Lake		3,900
1 river/precipitation gage, (bubbler type) Pittsfield, MA		5,500
	Subtotal	$13,300
Southwest Branch, Housatonic River		
1 river/precipitation gage, Richmond Pond		3,900
1 river/precipitation gage, (bubbler type) Pittsfield, MA		5,500
	Subtotal	$ 9,400
Main Stem, Housatonic River		
1 river/precipitation gage, Lee, MA		3,100
1 river/precipitation gage, Alford, MA		3,100
1 river/precipitation gage, (bubbler type) Lee, MA		5,500
	Subtotal	$11,700

II. BASE STATEION, Pittsfield, MA (Emergency power available)

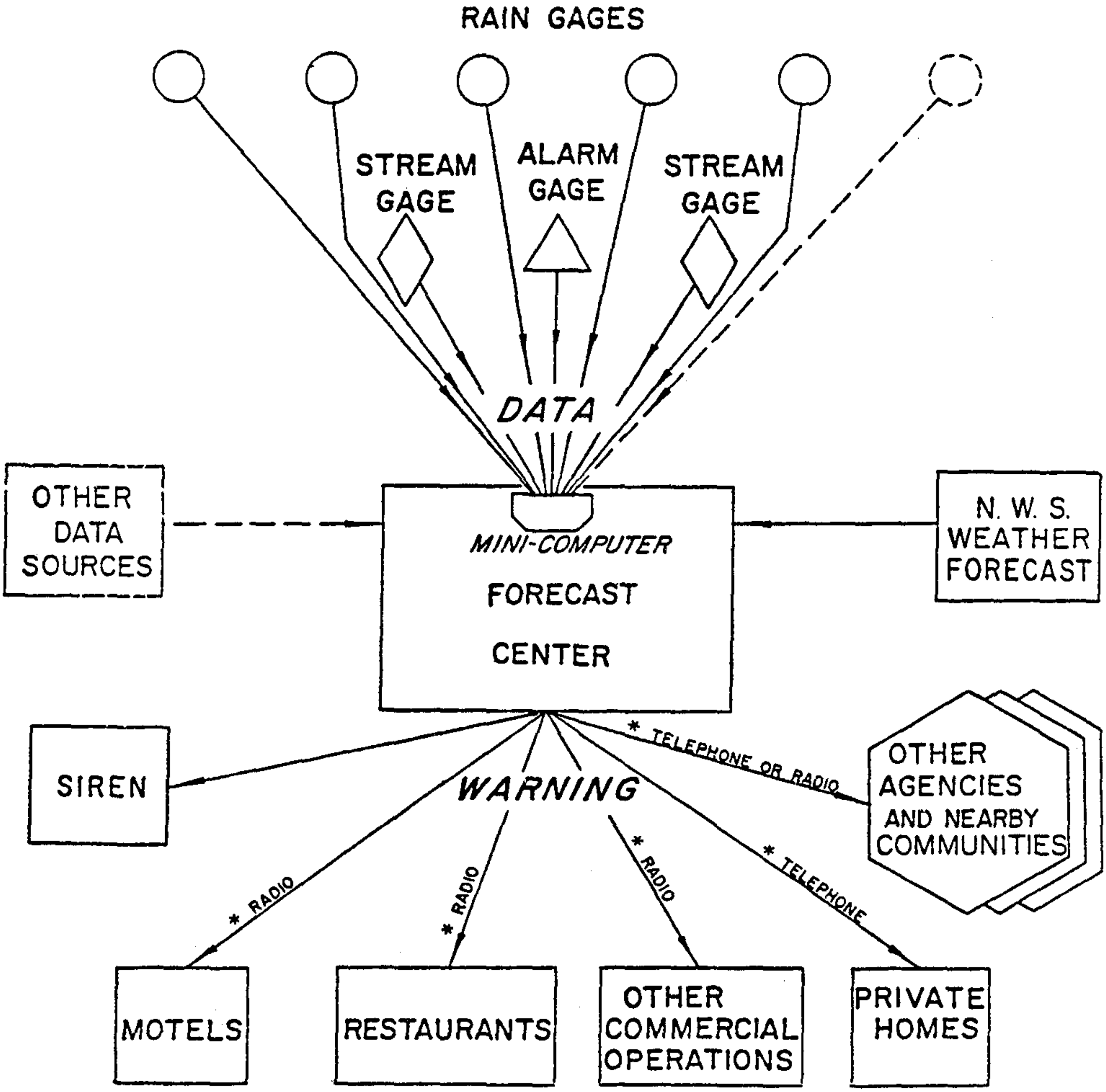
1 receiving antenna and cable		400
1 weather data receiver		2,500
1 computer with printer		5,500
1 modem		350
1 uninteruptable power supply		1,000
1 auxiliary clock/alarm		200
	Subtotal	$9,900
	Grand Total	$41,900

IV. ANNUAL OPERATION AND MAINTENANCE

Sensor site	40 @ 150 =	1,500
Base station		800
	Annual O & M	$2,300

If implemented the system should provide an additional 4.5 hours to Pittsfield and point downstream in Lee and Great Barrington.

FLOOD FORECASTING SYSTEM



* Primary

TABLE 11

ALTERT SYSTEM
UPPER HOUSATONIC MAIN STEM, CT

I. SENSOR NETWORK

		Estimated Cost
1 river gage, Falls Village, CT		3,000
1 river gage, (bubble type) Kent, CT		5,500
1 river gage, Bulls Bridge, CT		3,900
1 precipitation gage, Sharon, CT (Tenmile Basin)		3,100
1 precipitation gage, Cornwall, CT		3,100
1 radio repeater (if needed)		5,250
	Subtotal	$23,850

II. BASE STATION, New Milford, CT

1 receiving antenna and cable		400
1 weather data receiver		2,500
1 computer with printer		5,500
1 modem		350
1 uninteruptable power supply		1,000
1 auxiliary clock/alarm		200
	Subtotal	$ 9,950

III. BASE STATION, Kent, CT

1 Portable computer terminal (to get data from New Milford via telephone)		1,500
	Subtotal	$ 1,500
	GRAND TOTAL	$35,300

IV. OPERATION AND MAINTENANCE

Sensor site	6 @ 150/year =	$ 900
Base Station (New Milford)		800
	Annual O&M	$ 1,700

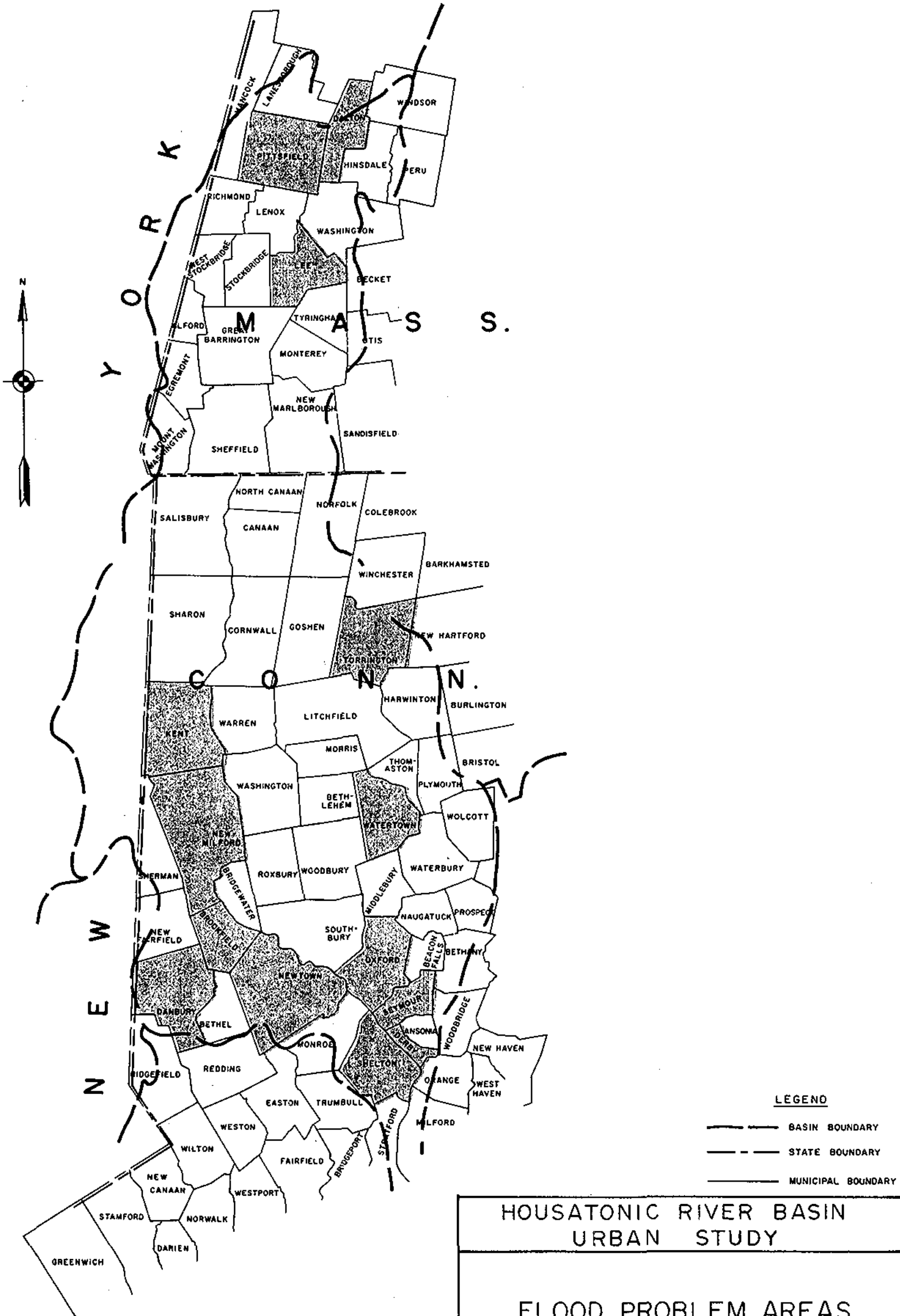
If implemented the system should provide an estimated 9.5 hours warning time on the Housatonic River near Kent and New Milford, Connecticut.

TABLE 12

ALTERT SYSTEM
DANBURY, CT

		Estimated Cost
I. SENSOR NETWORK		
2 precipitation gages, Danbury, CT		6,200
1 precipitation gage, Bethel, CT		3,100
1 river/precipitation, Danbury, CT		3,900
	Subtotal	$13,200
II. BASE STATION, Danbury, CT		
1 receiving antenna and cable		400
1 weather data receiver		2,500
1 computer with printer		5,500
1 modem		350
1 uninteruptable power supply		1,000
1 computer operating system		200
	Subtotal	$ 9,950
	GRAND TOTAL	$23,150
IV. OPERATION AND MAINTENANCE		
Sensor site	4 @ 150/year =	$ 600
Base Station (New Milford)		800
	Annual O&M	$ 1,400

For the Still River in Danbury, Connecticut, if implemented the system should provide an estimated 3.5 hours warning time.



HOUSATONIC RIVER BASIN URBAN STUDY

FLOOD PROBLEM AREAS

NOT TO SCALE

PLATE 15

Overall the flood damage reduction program recommended for Dalton consists of the following measures.

1. Flood proof housing complex for the elderly.
2. Flood proof active mill buildings.
3. Implement enhanced flood forecast system.
4. Develop evacuation plan to complement improved warning system particularly at elderly housing.
5. Adoption of NFIP flood plain zoning regulations.
6. Inform local community/industrial leaders of flood risks and current availability of flood insurance.

PITTSFIELD. A total of 73 residences were found to be candidates for further investigation to determine if they are economically justified for flood proofing measures. Seventy of these were suitable candidates for raising, while three were suitable for protection of utilities through use of utility rooms. The BCR for flood proofing this group of homes in aggregate is 1.71 and the first cost of this plan is estimated to be $2 million.

Most of the residences that can be flood proofed are located in two separate areas. At the first area, located near Silver Lake, there are 30 homes which can be flood proofed. At the second area, near Goodrich Pond, there are an additional 30 homes which can be flood proofed.

Additionally, in the second area near Goodrich Pond, there are six homes on Grand Avenue and Brattle Street which may be protected by a small levee. The remaining residences are scattered throughout the Pittsfield flood plain.

Twelve commercial-industrial structures in Pittsfield, for which damage estimates were available were evaluated and on a relative cost versus benefit basis and are believed to be good candidates for flood proofing. An additional 22 establishments in the Silver Lake area were identified as suitable flood proofing candidates based on their type of construction and location in the flood plain.

Pittsfield currently has a volunteer flood warning system. A more detailed plan developed as part of the upper basin warning system described earlier would provide about 4.5 hours of lead time for property owners to implement flood proofing and evacuation activities.

The city of Pittsfield is in the Regular phase of the NFIP and was required to adopt minimum flood plain regulations discussed earlier.

There are approximately 750 residences in the 100-year flood plains of Pittsfield. However, only 121 homeowners have obtained insurance totalling $3.6 million. There are approximately 135 commercial-industrial establishments subject to flooding from the 100-year event but only 14 establishments have obtained $1.4 million in flood insurance. Expected annual damages in Pittsfield exceed 20% of total insurance coverage. It is apparent that flood insurance is under utilized in Pittsfield.

A flood management plan for Pittsfield which appears to warrant future investigation includes:

1. Flood proofing of 73 homes.
2. Flood proofing of 34 commercial-industrial structures.
3. Flood warning and evacuation plan which would provide 4.5 hours of warning time.
4. Enforcement of current minimum NFIP regulations.
5. Local support of flood insurance for owners of flood plain property.
6. Technical assistance program to inform homeowners and businessmen of techniques to reduce the potential flood damages.

LEE. Four residences were found to be candidates for further investigation to determine if they are economically justified for flood proofing measures. All four were suitable for raising to an elevation above the 500-year event. The BCR for flood proofing these four homes in aggregate is 1.04 and the first cost of this plan is $105,590.

Of the commercial-industrial structures in Lee, nine were identified as potential flood proofing candidates. Six of these structures with flood damages compared to generalized costs appear to warrant further consideration.

Of the three structures without detailed damage estimates, two are large industrial buildings in the 50-year flood plain. These two structures would appear to be strong candidates for flood proofing measures.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. A more detailed plan, developed as part of the upper basin warning system, would provide about 4.5 hours of lead time for property owners to implement flood proofing and evacuation activities.

The town of Lee is in the Emergency phase of the NFIP, but is expected to enter the Regular phase in the near future. At that time, the town will be required to enforce minimum NFIP flood plain regulations.

Ten homeowners in Lee have obtained flood insurance totalling $248,000, compared to the 37 residences which have total expected annual damages of $30,000. It appears that residential use of flood insurance could be improved. None of the 17 commercial-industrial structures in the 100-year flood plain, with total expected annual damages in excess of $75,000, have flood insurance. The use of flood insurance by commercial and industrial establishments should be strongly emphasized.

At this stage in the study the plan which could receive additional consideration includes the following:

1. Flood proofing of four homes.
2. Flood proofing of nine commercial-industrial structures.

3. Flood warning and evacuation plan which would provide 4.5 hours of warning time.
4. Enforcement of minimum NFIP regulations.
5. Local support of flood insurance for owners of flood plain property, especially commercial-industrial establishments.
6. Technical assistance program to inform property owners of techniques to reduce potential flood damages.

KENT. The flood problem faced by residents as a result of storm related flooding does not appear to be serious (the effects of ice jams, which have a history of occurrence downstream of the residential area, were not considered in this analysis). Based on the flood hazard at this site, flood proofing does not appear to be warranted for residential properties.

For non-residential structures, 12 buildings were identified as suitable candidates for flood proofing measures. Ten of these structures are part of the private Kent School complex, and the remaining two structures are public facilities.

Currently, flood warnings for Kent are issued as part of the NWS general flood forecast. A more specific flood warning system designed to primarily service Kent and New Milford would provide 9.5 hours of lead time for property owners to implement flood proofing and evacuation activities.

With respect to future flood plain development, the town of Kent is in the Regular phase of the NFIP and is required to adopt minimum flood plain regulations. Since sections of the town are in areas subject to ice jam flooding, the effects of these jams on the flood hazard should be recognized in the regulations.

The use of flood insurance by residential property owners appears to be adequate; however, only one commercial-industrial property of the 12 structures in the flood plain have obtained flood insurance. The availability of flood insurance (Kent is in the Regular phase of the program) is vastly under utilized.

A flood management plan for Kent which appears to warrant further investigation includes:

1. Flood proofing Kent School, Kent Center School and the sewage treatment plant.
2. Flood warning and evacuation plan which would provide 9.5 hours of warning time.
3. Enforcement of current minimum NFIP regulations and addition of the ice jam hazard in applicable river reaches.
4. Local support of flood insurance for commercial-industrial property owners.
5. Technical assistance program to inform property owners of techniques to reduce potential flood damages.

NEW MILFORD. A unique aspect of the flood hazard within New Milford is the high depths of flooding experienced throughout the range of events. Many locations would experience about 16 feet at the 100-year and upwards of 30 feet at the 500-year flood. As a result flood proofing techniques have limited application here.

Only two homes in New Milford were found to be candidates for further investigation to determine if they are economically justified for flood proofing measures. The aggregate BCR for raising these two residences is 1.20 with a first cost of $71,000.

For commercial-industrial structures in New Milford, seven structures were identified as potential flood proofing candidates. Because of the extremely high flood depths, none of the remaining 70 structures in the flood plain were found to be suitable candidates for flood proofing.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. A more detailed plan, developed to primarily service New Milford and Kent, would provide 9.5 hours of lead time for property owners to implement flood proofing and evacuation activities. A detailed evacuation plan is essential in view of the depth of flooding and potential loss of life.

The town of New Milford is in the Regular phase of the NFIP and is required to adopt minimum flood plain regulations.

The use of flood insurance by residential property owners appears to be adequate, however, only 13 commercial-industrial establishments have obtained a total of $576,000 in flood insurance, which is only a small fraction of the damages that could be expected in a major flood.

A flood management plan for New Milford which appears to warrant further investigation includes:

1. Flood proofing of two residences.
2. Flood proofing of seven commercial or industrial structures.
3. Flood warning and evacuation plan which would provide 9.5 hours of warning time.
4. Enforcement of NFIP regulations and consideration of more stringent regulations in view of extreme flood depths and safety considerations.
5. Local support of flood insurance for commercial-industrial property owners.
6. Technical assistance program to inform property owners of techniques to reduce potential flood damage.

BROOKFIELD. There do not appear to be any justified (with a benefit to cost ratio above .8) flood proofing opportunities for the ten residential properties in Brookfield.

There are three areas for potential flood proofing of commercial-industrial properties along the Still River. The first area is a small shopping plaza which may be protected by closures or a small berm. The second area is comprised of three light industrial structures which could be flood proofed by use of closures. The third area is a commercial development comprised of nine structures which could be protected by closures or small walls.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. A more detailed plan, developed as part of the warning system on the Still River servicing Danbury and Brookfield, would provide 3.5 hours of lead time for property owners to implement flood proofing and evacuation activities.

The town of Brookfield is in the Regular phase of the NFIP and is required to enforce the program's minimum flood plain regulations.

The use of flood insurance by residential property owners appears to be adequate. However, less than half of the commercial-industrial establishments in the flood plain have obtained flood insurance.

A plan for Brookfield which appears to warrant further investigation includes:

1. Flood proofing of one industrial and two commercial areas.
2. Flood warning and evacuation plan which would provide 3.5 hours of lead time.
3. Enforcement of current minimum NFIP regulations.
4. Local support of flood insurance for commercial-industrial property owners.
5. Technical assistance program to inform property owners of techniques to reduce potential flood damage.

DANBURY. There do not appear to be any justified flood proofing opportunities for 30 residential properties in Danbury.

There are six areas where flood proofing of commercial-industrial structures could be feasible based on structure construction type and depth and frequency of flooding. In general, structures in Danbury are not subject to extreme flood depths, but based on the use of these buildings it is expected that damages may be significant and therefore these structures would be strong flood proofing candidates. The first site is a car dealership on the Still River which could be protected by a levee. At the second area, also on the Still River, there are five large industrial structures and eight commercial structures which could be flood proofed primarily by use of closures. The third area in Danbury is comprised of light industrial and commercial structures on Limekiln Brook. Seven industrial structures and eight commercial buildings can be flood proofed either by small levees or closures. At the fourth area in Danbury, there are five light industrial structures on Sympaug Brook which can be protected by closures.

In the fifth area on the Padanaram Brook, there are four commercial-industrial buildings and a fire station which can be protected by closures. The sixth area, on the Still River, is comprised of the airport and light manufacturing and residential development. Detailed elevations have not been obtained for these structures, but based on available information, it would appear that these structures can be flood proofed.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. A more detailed plan as part of the warning system on the Still River servicing Danbury and Brookfield would provide 3.5 hours of warning time for property owners to implement flood proofing and evacuation activities.

The city of Danbury has been in the Regular phase of the NFIP since 2 May 1977 and is required to adopt minimum flood plain regulations. Despite these regulations flood plain development appears to be continuing.

The use of flood insurance by property owners in the flood plain in Danbury appears to be adequate.

A flood management plan for Danbury which appears to warrant further investigation includes:

1. Flood proofing of over 39 commercial-industrial structures.
2. Flood warning and evacuation plan which would provide 3.5 hours of warning time.
3. Strict enforcement of current minimum NFIP regulations.
4. Technical assistance program to inform property owners of techniques to reduce potential flood damage.

NEWTOWN. There do not appear to be any flood proofing opportunities in Newtown for the 42 residential properties located in the 100-year flood plain.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. A more detailed flood forecast system does not appear to be necessary for the residential area in the flood plain of the Housatonic. However, a more detailed warning and evacuation plan may be appropriate.

The town of Newtown is in the Regular phase of the NFIP and is required to adopt the program's minimum flood plain regulations.

Use of flood insurance by property owners in Newtown appears to be adequate.

A plan for Newtown which appears to warrant further investigation includes:

1. A warning and evacuation plan which uses the current NWS forecast system.

2. Enforcement of current minimum NFIP flood plain regulations.
3. Technical assistance program to inform property owners of techniques of reduce potential flood damage.

OXFORD-SEYMOUR. A total of 14 residences on Connecticut Route 34 were found to be candidates for further investigation to determine if they are economically justified for flood proofing measures. All of these structures were suitable candidates for raising. Thirteen of the structures are located in Oxford while two additional residences are located in Seymour, just south of the Oxford-Seymour corporate limit.

There do not appear to be any commercial-industrial structures in Oxford that could be flood proofed. There are six commercial structures in Seymour which may be suitable candidates for flood proofing.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. There does not seem to be a need for a more detailed flood forecast system for the lower portion of the basin. However, a more detaled warning and evacuation plan may be appropriate in light of the flood depths expected at this residential area.

Both Oxford and Seymour are in the Regular phase of the NFIP and are required to adopt the program's minimum flood plain regulations.

The use of flood insurance by residential property owners is not inclusive of all residences in the flood plain.

A flood management plan for Oxford and Seymour which appears to warrant further investigation includes:

1. Raising of 14 residences on Route 34.
2. Flood proofing of six commercial structures in Seymour.
3. Warning and evacuation plan which uses the current NWS forecast system.
4. Enforcement of current minimum NFIP flood plain regulations.
5. Local support of flood insurance for residential property owners.
6. Technical assistance program to inform property owners of techniques to reduce potential flood damage.

DERBY. A more detailed investigation would be necessary to determine the feasibility of flood proofing the 19 cottages on McConney Grove. Because of the design and construction of these structures, a more detailed analysis would be required to determine the cost of flood proofing these structures.

Although detailed damage estimates are not available, other features of the properties indicate there is one commercial structure and a large industrial complex which may be suitable candidates for flood proofing measures. Existing flood warning is provided by the NWS as part of its general flood warnings. Although a more detailed forecast system does not appear to be necessary for the lower portion of the basin, a more detailed warning and evacuation plan may be appropriate, especially for the summer residences which could be subject to high flood depths, possible structural damage and potential loss of life.

The city of Derby is in the Regular phase of the NFIP and is required to adopt the program's minimum flood plain regulations.

The use of flood insurance by commercial and industrial establishments appears to be sufficient, however, residential usage of flood insurance is not inclusive of all residences in the flood plain.

A plan for Derby which appears to warrant further investigation includes:

1. Possible flood proofing of summer cottages.
2. Flood proofing of one commercial and one industrial structure.
3. Warning and evacuation plan which uses the current NWS forecast system.
4. Enforcement of current minimum NFIP flood plain regulations.
5. Local support of flood insurance for residential property owners.
6. Technical assistance program to inform property owners of techniques to reduce potential flood damage.

SHELTON. A more detailed investigation is necessary to determine the feasibility of flood proofing 60 cottages on Maple Street. Because of the design and construction of these structures, a more detailed analysis is required to determine the cost of flood proofing these structures.

Based on flood depths, structure construction and location in the flood plain, there are two areas in Shelton where flood proofing may be feasible for commercial-industrial structures. The first area, on the Housatonic, is comprised of 10 industrial structures which may be protected by closures. The second area, on Means Brook, is comprised of 10 commercial buildings which may be protected by closures or small berms.

Existing flood warning is provided by the NWS as part of its general flood warnings. Although a more detailed forecast system does not appear to be necessary for the lower portion of the basin, a more detailed warning and evacuation plan may be appropriate especially for the industrial complexes on the Housatonic and the summer residences which could be subject to high flood depths, possible structural damage, and potential loss of life. A second, yearround residential area would also benefit from such an early warning and evacuation plan. Although this second area is not subject to extremely hazardous flood heights, the only access road to this area would be inundated and prevent access and egress.

The city of Shelton is in the Regular phase of the NFIP and is required to adopt the program's minimum flood plain regulations.

The use of flood insurance by property owners within the flood plain is insufficient.

A flood management plan for Shelton which appears to warrant further investigation includes:

1. Possible flood proofing of summer cottages.
2. Flood proofing of 10 industrial buildings on the Housatonic and 10 commercial structures on Means Brook.
3. Warning and evacuation plan which uses the current NWS forecast system.
4. Enforcement of current minimum NFIP flood plain regulations.
5. Local support of flood insurance for property owners within the flood plain.
6. Technical assistance program to inform property owners of techniques to reduce potential flood damages.

WATERTOWN. There do not appear to be any feasible candidates for residential flood proofing. There are only 16 residential properties in the 100-year flood plain in Watertown and the preliminary investigations indicae none have a BCR over .8.

Although detailed damage estimates are not available, there appear to be a total of six commercial-industrial structures on Steele Brook which may be suitable candidates for flood proofing measures.

Existing flood warning is provided by the NWS as part of its regular general flood warnings. Based on the limited flood plain development, a more detailed forecast system for Steele Brook does not appear to be warranted.

The town of Watertown is in the Regular phase of the NFIP and is required to enforce the program's minimum flood plain regulations.

The use of flood insurance by property owners in the flood plain appears to be sufficient.

A flood management plan for Watertown which appears to warrant further investigation includes:

1. Flood proofing of six commercial-industrial structures on Means Brook.
2. Enforcement of current minimum NFIP flood plain regulations.
3. Technical assistance program to inform property owners of techniques to reduce potential flood damages.

TORRINGTON. Detailed hydraulic information was not readily available for the residential area in Torrington subject to flooding. This area is comprised principally of 35 mobile homes on the West Branch of the Naugatuck River. Because of the mobility of these structures, they would appear to be suitable candidates for raising or relocation, depending on the hydraulic conditions.

There are three commercial-industrial structures, two on the East Branch and one on the West Branch, which appear to be suitable candidates for flood proofing by means of closures.

Existing flood warning is provided by the NWS as part of its general flood warnings. The existing forecast system when combined with the protective works constructed by the Corps of Engineers appear to provide sufficient flood warning.

The city of Torrington is in the Regular phase of the NFIP and is required to adopt the program's minimum flood plain regulations.

The use of flood insurance by property owners within the flood plain appears to be sufficient.

A flood management plan for Torrington which appears to warrant further investigation includes:

1. Flood proofing of trailer park on West Branch.
2. Flood proofing of three commercial-industrial structures.
3. Flood warning and evacuation plan which utilizes current NWS and Corps forecasting system.
4. Enforcement of current minimum NFIP flood plain regulations.
5. Technical assistance program to inform property owners of techniques to reduce potential flood damages.

Federal Assistance Programs

The Corps of Engineers and the Soil Conservation Service have programs available to assist local communities with their flooding problems. After careful review of the type, size, and location of the damage areas throughout the basin, the following programs are suggested:

Section 205 of the 1948 Flood Control Act, as amended by Section 61 of the 1974 Water Resources Development Act provides authority to the Chief of Engineers to construct small flood control projects. Each project selected must be complete-within-itself and be economically justified. In addition, each project is limited to Federal cost of not more than $4 million. This Federal cost limitation includes all project related costs for investigations, inspections, engineering, preparation of plans and specifications, supervision and administration, and construction.

A project planned and constructed under Section 205 is designed to provide the same complete project and same adequate degrees of protection as would be provided under specific Congressional authorization. Flood control projects under Section 205 are not limited to any particular type of improvement. A project may include features for other purposes, such as water supply, when local interests indicate the need, as well as the willingness and ability, to contribute to that part of the project cost.

A project is adopted under Section 205 only after full detailed investigation and study clearly shows the engineering feasibility and economic justification of the project proposed. An investigation of a prospective small project under Section 205 may be initiated after receipt of a formal request from a prospective sponsoring agency fully empowered under State law to provide all required local cooperation. This request and any further inquiries concerning a small flood control project should be made directly to the Division Engineer.

Flood Plain Management Service. The Corps is authorized by Section 206 of the 1960 FC Act, as amended, to provide information, technical planning assistance, and guidance upon request to both Federal and non-Federal entities in identifying the magnitude and extent of the flood hazard and in planning wise use of the flood plains. Direct response and assistance of this kind are provided through the Flood Plain Management Services Program. The Corps also administers studies which provide basic hydrologic and hydraulic information to the Federal Emergency Management Agency on a reimbursable basis under interagency agreement.

The Watershed Protection and Flood Prevention Act, Public Law 83-566 Stat. 666 authorizes "the Secretary of Agriculture to cooperate with states and local agencies in the planning and carrying out of works of improvement for soil conservation and for other purposes." It provides for technical and financial assistance by the Department through the Soil Conservation Service (SCS) to local organizations representing people lining in small watersheds (less than 250,000 acres). The Act provides for a project-type approach to solving land, water, and related resource problems. Flood prevention is an eligible purpose for which SCS can pay 100 percent of the costs for planning studies, design, and construction of structural solutions while the local sponsoring organization is responsible for land rights, operations and maintenance. Nonstructural costs for implementation are divided 80 percent Federal and 20 percent non-Federal.

The Resource Conservation and Development (RC&D) Program was authorized by the Food and Agriculture Act of 1962. It expands opportunities for conservation districts, local units of government, and individuals to improve their communities in multicounty areas. The Program can assist them in enhancing their economic, environmental, and social well-being. Flood prevention measures are planned and carried out where there is a need for reducing or preventing water damage from inundation of property, business and/or threatening the loss of life. Flood prevention is related to the control and disposal of surface water caused by either stream overflow or abnormally high direct precipitation. RC&D may provide up to 100 percent of construction costs.

Flood Insurance. A National Flood Insurance Program is available to protect the individual in participating communities from financial disaster in the event of a flood. Insurance by definition is economically inefficient because it reimburses for loss but does not normally prevent the loss. Under the National Flood Insurance Program (P.L. 90-448, as amended) insurance is subsidized, up to an amount specified, on properties in areas designated as hazardous by the Federal Insurance Administration. The land use control measures required of communities to gain and maintain eligibility for flood insurance are complementary to other flood plain management efforts. Section 202 of Public Law 93-234 states that no Federal officer or agency shall approve any financial assistance for acquisition or construction purposes after July 1, 1975 for use in the area identified by the Federal Emergency Management Agency as an area having special flood hazards unless the community in which such area is situated is then participating in the National Flood Insurance Program. It is considered that this prohibition does not apply to flood-related activities of the Corps of Engineers.

CONCLUSIONS

Resolutions authorizing this study have made possible the examination of water supply needs and flood damage areas including the evaluation of alternative solutions. Demographic studies and water demand projections did indicate that in a number of communities existing water supplies will have to be supplemented to meet future demands but the projected deficits are not as large, or as widespread as originally believed.

Plans to meet projected water supply demands have been developed utilizing groundwater, reservoirs and river withdrawals/diversions. Plans have been developed as supply sources for individual communities and small regional systems. Large regional systems utilizing new sources were formulated and evaluated but none passed initial screenings of cost, water quality, social and environmental impacts as well as public acceptability.

Careful examination of the flood plains in the study area yielded some significant potential damage areas. Various solutions to the potential flood problem areas were evaluated. Structural measures such as dams, diversions and dikes and nonstructural measures such as flood proofing, flood warning and evacuation and relocation were investigated in detail. Due to the location and magnitude of the damage areas, the nonstructural type measures were found to be more feasible.

The flood management plans identified for the 14 communities will not be studied in any further detail under the urban studies authority which is being terminated. But further study, which could lead to Federal implementation, can be continued under Section 205 authority if there is local interest in such studies.

RECOMMENDATIONS

Projected short and long term water supply needs have been evaluated and found to be within the capabilities of local resources and responsibilities. Information developed will allow non-Federal interests to use study results as a guide for future water resources action. Since there are no water supply problems meeting the criteria for Federal assistance, I recommend that the water supply portion of the Housatonic Urban Study be terminated.

After careful review of the potential flood management protection plans and the location of the flood damage areas, I recommend that further studies be continued under Section 205 (special continuing authorities), which is more responsive to the needs of the basin, and that the Housatonic Urban Study authority be terminated. Strong interest has already been expressed by the public, the town of New Milford and the State of Connecicut, in the need for nonstructural flood management measures as the result of Stage 2 studies.

CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer

APPENDIX A

PROBLEM IDENTIFICATION APPENDIX

PROBLEM IDENTIFICATION APPENDIX

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INTRODUCTION

This appendix contains the detailed background information necessary to support the Plan Formulation Appendix. In the interest of clarity and presentation, the appendix is presented in essentially two sections. The first section contains information on the study authority, the study area and scope.

The second section contains information on the existing regional profile and projected future conditions. It also identifies specific water and related land resources problems, needs and opportunities to be addressed in plan formulation.

STUDY AUTHORITY

Authority for this report is derived from three Congressional resolutions adopted by the Committee on Public Works of the United States Senate and House of Representatives. These resolutions provided authority for the Housatonic River Basin in Massachusetts and Connecticut of which this report is in response. The resolutions pertaining to this study and report are the following:

Resolution adopted 25 May 1972 by the Committee on Public Works of the United States Senate:

> "That the Secretary of the Army, acting through the Chief of Engineers, is hereby authorized, in connection with the preparation of plans to meet the long-range water needs of the northeastern United States as authorized by Section 101 of Public Law 89-298, to cooperate with the State of Connecticut in conducting a study to recommend improvements in wastewater management and alternatives thereto within the Housatonic River Basin. The scope of such study shall be established with the consultation of the State of Connecticut and the Environmental Protection Agency and shall include measures for wastewater management including cleanup and restoration in the interest of water supply, environmental quality, recreation, fish and wildlife, and other allied water purposes, and shall be conducted with the participation, consultation, and cooperation of the Environmental Protection Agency and State and local water pollution control agencies and, where appropriate, State and local agencies with environmental planning responsibilities."

Resolution adopted 14 June 1972 by the Committee on Public Works of the House of Representatives:

"That the Secretary of the Army, acting through the Chief of Engineers, is hereby authorized, in connection with the preparation of plans to meet the long-range needs of the northeastern United States as authorized by Section 101 of Public Law 89-298, to cooperate with the State of Connecticut in conducting a study to recommend improvements in wastewater management and alternatives thereto within the Housatonic River Basin. The scope of such study shall be established with the consultation of the State of Connecticut and the Environmental Protection Agency and shall include measures for wastewater management including cleanup and restoration in the interest of water supply, environmental quality, recreation, fish and wildlife, and other allied water purposes, and shall be conducted with the participation, consultation, and cooperation of the Environmental Protection Agency and State and local water pollution control agencies and, where appropriate, State and local agencies with environmental planning responsibilities."

Resolution adopted 11 April 1974 by the Committee on Public Works of the House of Representatives:

"That the Secretary of the Army, acting through the Chief of Engineers, is hereby authorized, in connection with the preparation of plans to meet the long-range needs of the northeastern United States as authorized by Section 101 of Public Law 89-298, to conduct a study in cooperation with the Commonwealth of Massachusetts to provide a plan for the development, utilization, and conservation of water and related land resources within the Housatonic River Basin. The scope of such study shall be established with the consultation of the State of Massachusetts and the Environmental Protection Agency and other interested Federal agencies. Such study to include, but not be limited to; consideration of the needs of flood control of both an urban and rural nature including local storm drainage, wide use of flood plain lands, wastewater management facilities, including stormwater runoff, regional water supply, water quality control, recreation, fish and wildlife conservation, protection and enhancement of aesthetic qualities, and other measures for enhancement and protection of the environment on streams in the urban area and shall be conducted with the participation, consultation and cooperation of the Environmental Protection Agency and State and local water pollution control agencies and, where appropriate, State and local agencies with environmental responsibilities."

SCOPE OF STUDY

This survey study focuses on the identification of water supply and flood control problems in the study area and evaluates these problems in relationship to the overall environmental, social, and economic needs of the people living and working therein. The study results in the development of alternative solutions to provide adequate water supply for the study area communities and to protect flood-prone areas and prevent flood damages. The costs, benefits and environmental impacts associated with implementing the various alternatives were also investigated.

This report is based on area field reconnaissance, topographic surveys, soils investigations, hydrologic and hydraulic investigations, water quality studies, water usage studies, consultation with local interests, review and evaluation of prior studies and reports, and other related studies. Data concerning basic demographic and economic conditions within the study area were obtained from field investigations, published reports and consultation with local officials. Records of the United States Geological Survey and National Weather Service were utilized for the determination of climatologic, hydrologic and hydraulic data, and water supply information was obtained from past and current records of the Connecticut Department of Health Services, numerous reports and water supply agencies within the study area. Data concerning flood conditions for past floods were determined by field damage surveys, consultation with local officials and published reports. Initial plan formulation and last stage studies in preparation of this report were coordinated with other Federal, State, regional and local agencies having expertise in water resources development, special interest groups, and the general public.

EXISTING CONDITIONS

Basin Description

The Housatonic River watershed, as shown in the Main Report on Plate 1, encompasses approximately 1950 square miles located in Berkshire County, Massachusetts, and Litchfield, Fairfield and New Haven Counties in Connecticut. The main stem of the Housatonic River empties into Long Island Sound between Stratford and Milford, Connecticut.

The mainstem varies in gradient, size and bottom type along its 131 mile length. The 119 mile length of river between Pittsfield, Massachusetts and Derby, Connecticut falls a vertical distance of about 960 feet. The remaining 12 miles below Derby is relatively flat and under tidal influence. Major stretches of rapids occur along three reaches of the main stem: (1) between Pittsfield and Great Barrington, Massachusetts; (2) between Falls Village and Kent, Connecticut; and (3) in the vicinity of the Tenmile River. The remainder of the river has a slower current caused by low gradient and impoundments by dams. River widths range from 25 feet near the confluence of the East and West Branches to as wide as 1600 feet in Lake Lillinonah and near the river's mouth. Depths generally vary from 2-4 feet except in impoundment areas where they can reach up to 97 feet, such as in Lake Lillinonah.

There are a total of 407 lakes and ponds scattered throughout the Housatonic River Basin. They range in size from less than an acre to about 5600 acres (Lake Candlewood). About half are 10 acres or greater in size. Average depths range from a few feet to about 40 feet with maximum depths reaching over 100 feet. Most of the lakes are artificial impoundments or natural ponds that have been artificially raised.

Climatology

The wide variation in the climatic conditions in the basin is primarily caused by local differences in topography, elevation and geologic conditions. The climate is much more extreme in the hillier northern part than in the south. The area has more early summer precipitation than most of the rest of the basin, and a somewhat higher average number of thunderstorms, which may at times cause local flooding in small watersheds. Winters around Pittsfield are cold, and precipitation is usually in the form of snow, with average accumulations around 70 inches, whereas along the coast snow fall averages 34 inches. The average annual precipitation varies from approximately 47 inches in the north to about 44 inches along the coast.

Along Long Island Sound to about 10 miles inland, the climate is moderated by the water, with warmer winters and cooler summers. The average annual temperature in the basin varies from 50°F near the coast to 44°F at points in the northern portion of the basin.

A summary of climate data is given in Table A-1. Detailed climatological information is presented in Appendix C, "Technical Appendix.

TABLE A-1

CLIMATE CHARACTERISTICS

SUBBASINS

	Upper MA Mainstem	Lower MA Mainstem	Upper CT Mainstem	Lower CT Mainstem	Shepaug	Upper Naugatuck	Lower Naugatuck	Total Basin
Temperature (°F)								
Ave. Summer	68	68	68.2	71.3		71.4		69
Ave. Winter	28	28	26.4	31.3		30.6		29
Ave. Annual	45	45	47	48	48	47	49	47
Precipitation (inches)								
Ave. Annual	47	46	49	47	48	49	49	46
Snowfall Ave. Annual	65	75	80	35	55	50	40	30-100
Growing Season (days)								
Ave. Length	120	130	150	180	155	155	160	150

Topography

The dominating topographic feature of the basin is the Housatonic River valley. The northern perimeter of the basin is ringed with steep sided mountains raising 1500 feet above the wide valley to elevations of 2600 feet. In the lower Connecticut part of the basin, the tops of the even crested hills rise approximately 500 feet above the valley floor. This distinctive decline in elevations along the river from the mountains in Massachusetts to the hills in southern Connecticut, reflects the passage of the river through two sections of the New England physiographic province of North America - The Taconic section and the New England Upland section. The transition zone dividing these two areas occurs in the general vicinity of Bulls Ridge. The Taconic section to the north is the smallest subdivision of the New England province and consists of mountains and limestone valleys. The New England Uplands below Bulls Ridge extends from the tip of Maine through Connecticut and is generally described as a widespread plateau-like area with several thousand scattered lakes and isolated hard rock hills.

The remainder of the basin is a maturely-dissected plateau with narrow, flat-topped ridges and even-crested hills. Elevations range from 2700 feet in Massachusetts to 1000 - 1500 feet in central Connecticut to 500 - 600 feet near Long Island Sound. The terrain is variably hilly, with locally rugged areas primarily along the major water courses. Valleys are well developed and well graded with only a few extensive wetland areas located in the Still River valley, parts of the Bantam River valley near Bantam Lake, Robbins Swamp near the Massachusetts-Connecticut border, and the tidal estuary at the mouth of the river.

Geology

Bedrock Geology. The geology of the Housatonic basin is quite complex, reflecting events and process that have occurred over hundreds of millions of years. Most of the basin is underlain by metamorphic rock formed during the Precambrian Era one billion to 700 million years ago. Gneiss predominates in the east side of the basin, and is closely associated with quartzite in the north. The western uplands are underlain by schist, with some granitic intrusions. In northwestern Connecticut, ground water from fractures in the schistose rocks is likely to be high in iron and manganese.

The central section of the basin contains a series of north-trending belts of carbonate rock (marble, limestone, and dolomite) of varying widths which were subjected to intense folding and faulting during the collision of the ancient American and African continents 300 to 400 million years ago. Fracture zones and solution cavities in these carbonate rocks may yield larger quantities of ground water than other bedrock, but such areas are difficult to locate and the water may have excessive levels of dissolved solids. Some of the higher grade carbonate deposits are important sources of crushed lime and cut marble.

The valley of the Pomperaug River in the South is underlain by distinctly different sedimentary and igneous rocks similar to those found in the Connecticut River valley. Finally, the tidal section of the Housatonic River below Derby is excavated in phyllite.

Surficial Geology. Surficial geologic deposits are of two major types, both resulting from the last of four glacial advances during the Pleistocene Epoch, 10,000 to 12,000 years ago. Till (unsorted materials of all sizes) covers most of the land surface, usually compacted into a hardpan. Stratified drift (well-sorted fine- to coarse-grained materials deposited by glacial meltwaters) overlies the till in the major stream valleys, covering about 16 percent of the land surface in the lower basin, 11 percent in the middle sections, and somewhat more in Massachusetts. Stratified drift in the tributary valleys is generally coarser than that along the Housatonic mainstem. In addition to being the most productive ground water aquifers, these deposits are also important sources of sand and gravel for construction and other purposes.

Floods

The Housatonic River basin is susceptible to destructive floods during any season of the year as a result of ice, heavy rainfall, melting snow or some combination thereof. Within the past 50 years, the Housatonic River Watershed has experienced numerous flood events, the most significant of these occurring in 1927, 1936, 1938 1948-9, 1955, 1969, and 1972, 1977. The floods of record for the basin are the September 1938 flood for the upper basin in Massachusetts and the August 1955 flood for the Connecticut portion of the basin. The most recent flooding occurred in June of 1982. Although the extent and depth of flooding was not exceptional, it did refresh memories of past floods and emphasize the risks associated with potential floods of greater magnitude.

The August 1955 flood, the record flood on the Naugatuck and on the Housatonic River below Kent, was caused by torrential rains which accompanied Hurricane Diane. Forty-seven lives were lost and damages were estimated at $245 million, of which $220 million were in the Naugatuck Valley. Major damage centers were Torrington, Thomaston, Watertown, Waterbury, Naugatuck, Beacon Falls, Seymour, Ansonia and Derby on the Naugatuck; Washington Depot on the Shepaug; Danbury on the Still; and New Milford, Derby and Shelton on the Housatonic mainstem. The August flood, three to four times larger than any previous flood on the Naugatuck, was followed in October 1955 by another severe flood that disrupted rehabilitation measures.

The October 1955 flood, the record flood on the Still River, caused losses estimated at $6.5 million at Danbury. Waterbury, Seymour, Ansonia and Shelton were also major damage centers. For the basin above Kent, the New Year's flood of 1949 is the flood of record. Major damage centers were Great Barrington, Lee, Pittsfield and Stockbridge, Massachusetts and Canaan, Connecticut.

In 1955, there were no Federal flood control works in the basin, although Thomaston Dam was authorized for construction. Substantial progress has been made since then. Hall Meadow Brook, East Branch, Thomaston, Northfield Brook, Black Rock, Hancock Brook and Hop Brook Dams have been completed as have local protection projects in the Naugatuck Basin at Torrington, Waterbury-Watertown, Ansonia-Derby, and in the Housatonic River Basin at North Canaan, Derby and Danbury, Connecticut and Lee, Massachusetts, and along the Green River at Hillsdale, New York and Alford, Massachusetts.

A master plan for development and management of each Corps reservoir project in the basin has been completed, except for minor revisions that are being coordinated with appropriate State resource agencies. The report discusses management plans, beautification measures and the potentials for each project for recreation, fish and wildlife enhancement and agricultural and forestry management.

A tabulation of the authorized flood control program follows this text.

AUTHORIZED FLOOD CONTROL PROJECTS
Housatonic River Basin

Name	River (All in Naugatuck River sub-basin Connecticut	Drainage Area (sq. mi.)	Flood Control Storage (ac. ft)
COMPLETED DAMS AND LAKES			
Hall Meadow Brook	Hall Meadow Brook	17.2	8,620
East Branch	East Branch, Naugatuck	9.3	4,350
Thomaston	Naugatuck	97.0	42,000
Northfield Brook	Northfield Brook	5.7	2,430
Black Rock	Branch Brook	20.4	8,700
Hancock Brook	Hancock Brook	12.0	4,030
Hop Brook	Hop Brook	16.4	6,970

LOCATION	RIVER
COMPLETED LOCAL PROTECTION WORKS	
Alford, MA-Hillsdale, NY**	Green
Lee, MA**	Housatonic
Torrington, CT*	East Branch, Naugatuck
Torrington, CT*	West Branch, Naugatuck
Waterbury-Watertown, CT*	Naugatuck
Ansonia, CT	Naugatuck
North Canaan, CT	Blackberry
Danbury, CT	Still
Derby, CT	Housatonic & Naugatuck

* Small flood control projects not specifically authorized by Congress
** Emergency Bank Protection projects not specifically authorized by Congress.

Potential flood damage areas in the basin are located mainly along the East Branch and the mainstem of the Housatonic River. Approximately 2000 structures including homes, commercial and industrial establishments within the area would receive flooding to various degrees from the 100-year flood event.

Droughts

The long term average annual rainfall of the Housatonic River Basin is approximately 45 inches. When rainfall is below average for a period of time, the area experiences what is referred to as drought conditions. A drought is defined as a prolonged period of precipitation deficiency which seriously effects both river flow and groundwater supplies. The drought of 1961-1967 in Southern New England was one of the worst experienced since the beginning of systematic streamflow monitoring near the turn of the twentieth century. The last comparable drought was around 1914-1916. The 1960's drought followed a period of above normal rainfall during the 1950's and was particularly severe because it resulted in two successive years (1965 and 1966) of near record lows in annual precipitation. The average flow in the Housatonic River was about 38 percent of normal for the period October 1964 to September 1966.

The drought the study area recently experienced is the result of below normal rainfall from the spring of 1980 through the summer of 1981. Plate A-1 delineates the precipitation data for 1980-1981 in the southwestern portion of the study area. The total precipitation for 1980 was only 4 inches less than normal, but as can be seen on Plate A-1 it is due to the fact that the area experienced very high rainfall for March and April. The remainder of the year was significantly below average. The 1981 total precipitation was approximately three inches below average, but the deficit was spread evenly throughout the year.

NATURAL RESOURCES

Soils

Soils in the basin may be divided into six associations, based on the nature of the parent materials. The upland soils (Paxton-Woodbridge, Charlton-Hollis, and Lyman-Peru-Marlow-Berkshire) are derived from glacial till and schist. They are poorly suited to intensive development because of shallow depth-to-bedrock or hardpan, stoniness, and steep slope. Soils derived from limestones and schists in the valleys (Copake-Groton) and western highlands (Stockbridge-Farmington-Amenia-Pittsfield) are deep, well drained, and are exceptionally productive agricultural soils, containing more available nutrients such as calcium and magnesium. They are less acidic and especially wellsuited to the production of grain crops, silage, and pastureland for dairy farming. Soils derived from granite and gneiss (Hinckley-Merrimac) are found along the valley edges on terraces of glacial outwash. They are sandy and well-drained, deep, acidic, and underlain by thick beds of sand and gravel.

The natural resources of the Housatonic River Basin can be divided into aquatic and terrestrial ecosystems. Major habitats and associated communities in each ecosystem are described below.

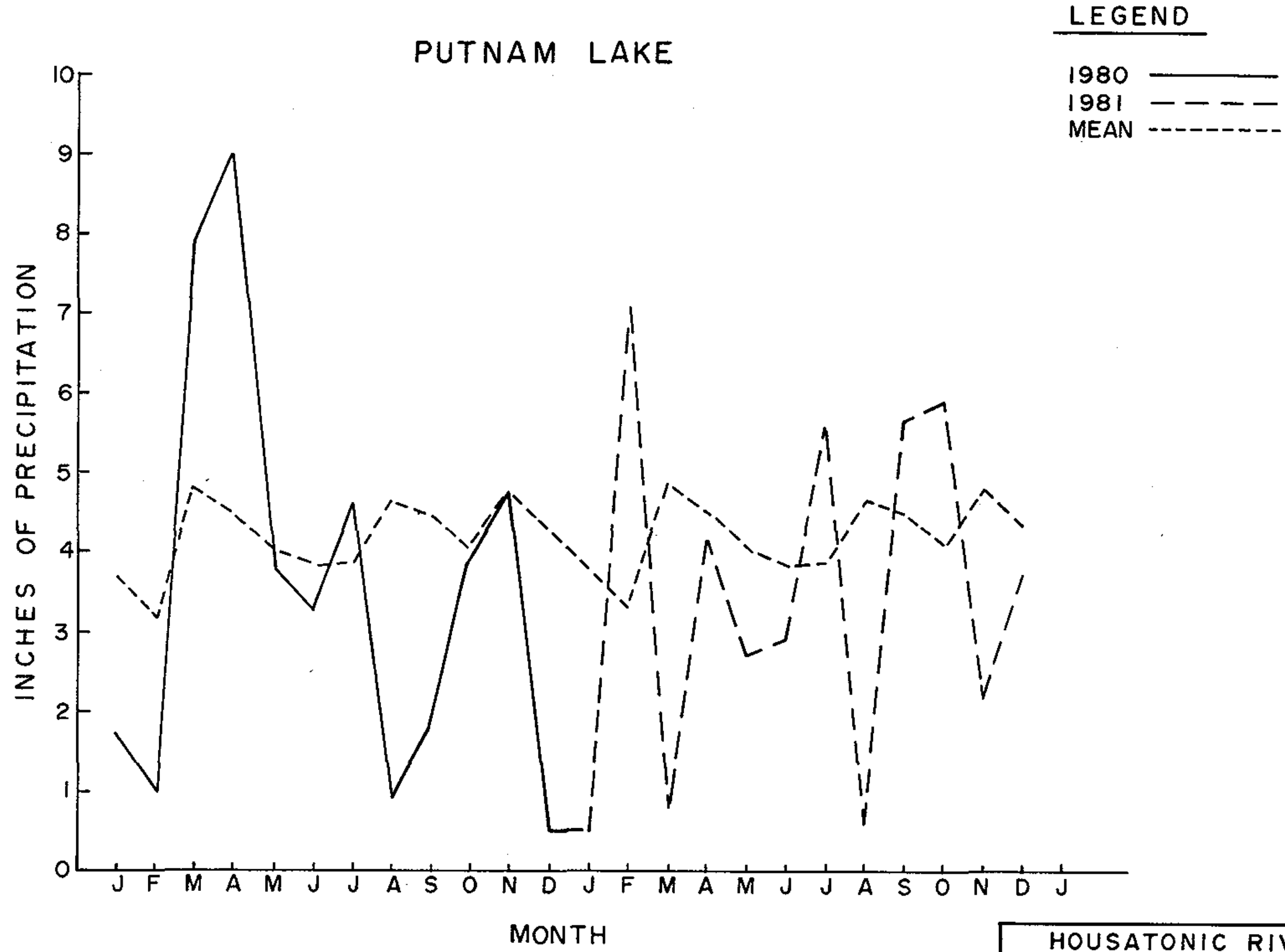
Aquatic Ecosystem

The aquatic ecosystem in the basin is comprised of both freshwater and estuarine (brackish water) habitats. Freshwater habitats include the upper portions of the Housatonic mainstem, associated tributaries and the various lakes and ponds throughout the basin. Estuarine habitat involves the lower portion of the mainstem which is influenced by the brackish waters of Long Island Sound.

Freshwater Habitat and Fisheries

The largest riverine habitat in the basin is the Housatonic River mainstem which is the main collection area for all the precipitation and runoff in the entire 1950 square mile watershed. The mainstem originates at the confluence of the East and West Branches near Pittsfield, Massachusetts and flows in a southerly and southeasterly direction through western Connecticut into Long Island Sound between Stratford and Milford, Connecticut.

Streamside habitat includes forested bottomland, flood plains, marsh, swamps, and farmland. The entire mainstem and major portions of the larger tributaries are well exposed to the thermal influence of the sun. Water temperatures generally range from freezing during winter up to the mid and high 70's during summer and may peak in the mid-80's in the run-of-river impoundments.



HOUSATONIC RIVER BASIN
URBAN STUDY

PRECIPITATION DATA
VS.
MEAN MONTHLY

PLATE A-1

Tributary to the mainstem are many secondary streams which vary from just a few feet wide to that equal to the mainstem. Major tributaries include the East and West Branches at the headwaters, Williams River, Green River, Blackberry River, Tenmile River, Candlewood Lake (formerly Rocky River), Shepaug River, Pomperaug River and the Naugatuck River. Many of the small tributaries are well covered with streambank vegetation and therefore water temperatures may only reach the 60's or low 70's during the summer.

There are a total of 407 lakes and ponds scattered through the Housatonic River Basin. They range in size from less than an acre to about 5,600 acres (Lake Candlewood). About half are 10 acres or greater in size. Average depths range from a few feet to about 40 feet with maximum depths reaching over 100 feet in some reservoirs. Most lakes are artificial impoundments or natural ponds that have been artificially raised. The majority of lakes greater than 15-20 feet in depth will thermally stratify during summer and winter. Density differences disappear near the end of the season so that mixing will occur in spring and fall. Water temperatures range from freezing temperature during winter to the mid 80's during summer. The low colder, denser stratum, known as the hypolimnion, changes less dramatically but often becomes anaerobic during summer.

With the exception of the water supply reservoirs in the basin, most bodies of water in the basin have permanent or seasonal development around its shorelines. This development has increased the input of nutrients into the lakes and has caused a eutrophication problem in most of the basin's lakes. The degree of eutrophication can be measured by the concentration of nutrients in its water. Small shallow ponds with high aquatic weed growth, as well as Lakes Zoar and Lillinonah, are considered highly eutrophic with the highest concentrations of nutrients. The majority of lakes in the basin are classified eutrophic to mesotrophic with high to moderate levels of nutrients. The natural lakes in the northwestern portion of Connecticut (e.g. Twin Lakes) are considered oliogotrophic with comparatively low levels of nutrients. Water quality in oliogotrophic lakes remain very high, whereas in eutrophic lakes deteriorates during the summer stratification as the dissolved oxygen decreases. The streams, lakes, and ponds in the basin provide habitat for a variety of cold and warm water species of freshwater fishes. The most common species are listed at the end of this Appendix in the 5 July 1978 letter from the U.S. Fish and Wildlife Service. A more comprehensive list and their distributions may be found in Whitworth et al. (1976)

Natural and stocked populations of three species of trout are found in the basin: the native brook trout and the introduced European brown and western rainbow trouts. Brook trout prefer highly oxygenated cold waters and therefore are more commonly found in the wellcovered higher gradient tributaries in the basin. Brown trout are more tolerant to higher temperatures than brook trout and can be found in the larger streams including the mainstem. This species is very popular because of its large size and is stocked in larger quantities than brook trout. Rainbow trout the most tolerant of the three species, are stocked in lakes and reservoirs in addition to streams. The western kokanee salmon and northern pike are also stocked in selected lakes in the northern part of the basin.

The heavy fishing pressure generally depletes much of the stocked populations by mid-summer. The remaining fish retreat to the cooler tributaries during the high summer temperatures where spawning takes place on suitable substrate later in the fall. The State of Connecticut stocked 54 stream segments and 11 lakes with 149,400 trout in 1977- 1978 and Massachusetts stocks 32 streams and numerous lakes and ponds (CT DEP, 1978; USDA, 1977; cited in NERBC, 1980). The recent concern over PCB's in the upper Connecticut section of the Housatonic River reduced annual stocking from 21,000 to 6,000 fish by the State of Connecticut (NERBC, 1980).

USDI (1977) and USDA (1977) list several outstanding coldwater fisheries in the basin including Onata Lake (Kokanee salmon, large brown trout and northern pike), Laurel Lake (Kokanee salmon and brown trout), the Southeast Branch of the Housatonic River (natural brown trout fishery), the Green River (natural brown and rainbow trout) and the section of the mainstem between Falls Village and Kent (brown brook and rainbow trout).

Warmwater species of fish have a wider distribution in the basin than coldwater species because of their less stringent requirements for dissolved oxygen and water temperature. Typical species include carp, largemouth and smallmouth bass, bullheads, catfish, yellow perch, suckers, sunfish and minnows. They are more commonly found in the slower flowing sections of the Housatonic River and the basin's lakes and ponds. Whitworth et al. (1976) documented the distribution of species in Connecticut and their preferences for particular habitat types. Largemouth and smallmouth bass are particularly important warmwater game species. The warmwater fishery, in general, is underutilized and is more than adequate to satisfy the current demand.

The estuary in the Housatonic mainstem is a result of the tidal influence of Long Island Sound. This tidal influence has an upper limit in Derby and gradually increases towards the Sound. Salinities range from freshwater during slack tide to 28 parts per thousand (ppt) during a flood tide near the mouth. Sediments are generally muddy and require periodic dredging to maintain a navigable channel. Sand deposits are still present in the upper estuary and are currently being mined in the vicinity of Ten Mile Island.

The river is generally wide near the mouth (up to 1,600 ft. in sections) and is bordered by a mix of marinas, developments and saltmarsh.

The estuary supports a variety of shellfish including oysters, razorback and softshell clams, quahogs and mussels. The distribution of these species are generally dependent on bottom type and salinity. Oysters are the most important commercial fishery in the estuary and in Long Island

Sound. Oysters harvested from the Housatonic River must be transferred to cleaner waters prior to sale because of the coliform bacteria contamination. Significant finfisheries include the commercially important menhaden as well as the anadromous species: American Shad, alewifes, blueback herring, sea-run brown trout and young striped bass. Runs occur upstream as far as Derby. The presence of the dams and the warm water of the impoundments preclude restoration of anadromous fisheries upstream of Derby.

The Housatonic River Basin contains three general types of vegetative cover: forest, open field/agricultural land and wetlands. The NERBC (1980) compiled forestry statistics from the U.S. Forest Service and determined that nearly two-thirds of the basin's 1,276,056 acres is forested. Presently, figures do not exist for the open field/agriculture land cover type although NERBC (1980) has indicated that agricultural land alone is 11.4 percent of the basin. This figure would be higher if abandoned open fields and pasture land were added to this percentage. Compilations of the various region planning agency studies in the basin have indicated that wetlands occupy about 3-4 percent of the basin.

Vegetation. The forest vegetation within the basin is varied and may be divided into five distinct zones based on the classification scheme developed by Westveld et al. (1956). Plate A-2 indicates geographic range of each zone found in the basin.

Zone one 1 consists of the spruce-fir-Northern Hardwoods mix found in much of Maine, northern New Hampshire and Vermont. Only a small portion of this forest type exists in higher elevations in the extreme northeast corner of the basin. Characteristic species include red spruce, eastern hemlock, white spruce, white cedar, and a mixture of northern hardwoods such as black cherry, maples, birches, and beech. Balsam fir also characteristic of the group, is at the southern extreme of its range in the basin and therefore is not commonly found.

Zone 2 consists of the Northern Hardwoods-Hemlock-White Pine forests that occupy the northern perimeter of the basin in Massachusetts down to a small portion of northwestern Connecticut. Dominant species resemble Zone 1 except that white pine and hemlock are more characteristic of the softwoods than red spruce (Westveld et al., 1956). Dominant hardwoods include beech, sugar and red maples, yellow birch, white ash, black cherry, sweet birch, paper birch and northern red oak. Old fields are frequently dominated by pioneering white pine and hemlock.

The Transition Hardwood-White Pine-Hemlock association comprise Zone 3. This zone extends from the central portion of the Massachusetts section of the basin down to a major portion of southwestern Connecticut. Characteristic species included a mixture of species located to the north and south, respectively. Northern species such as beech, red, white and yellow birches and the maples overlays with southern species such as oaks and hickories of the Central Hardwoods zone (Zone 4). White pine is the dominant old field pioneering species.

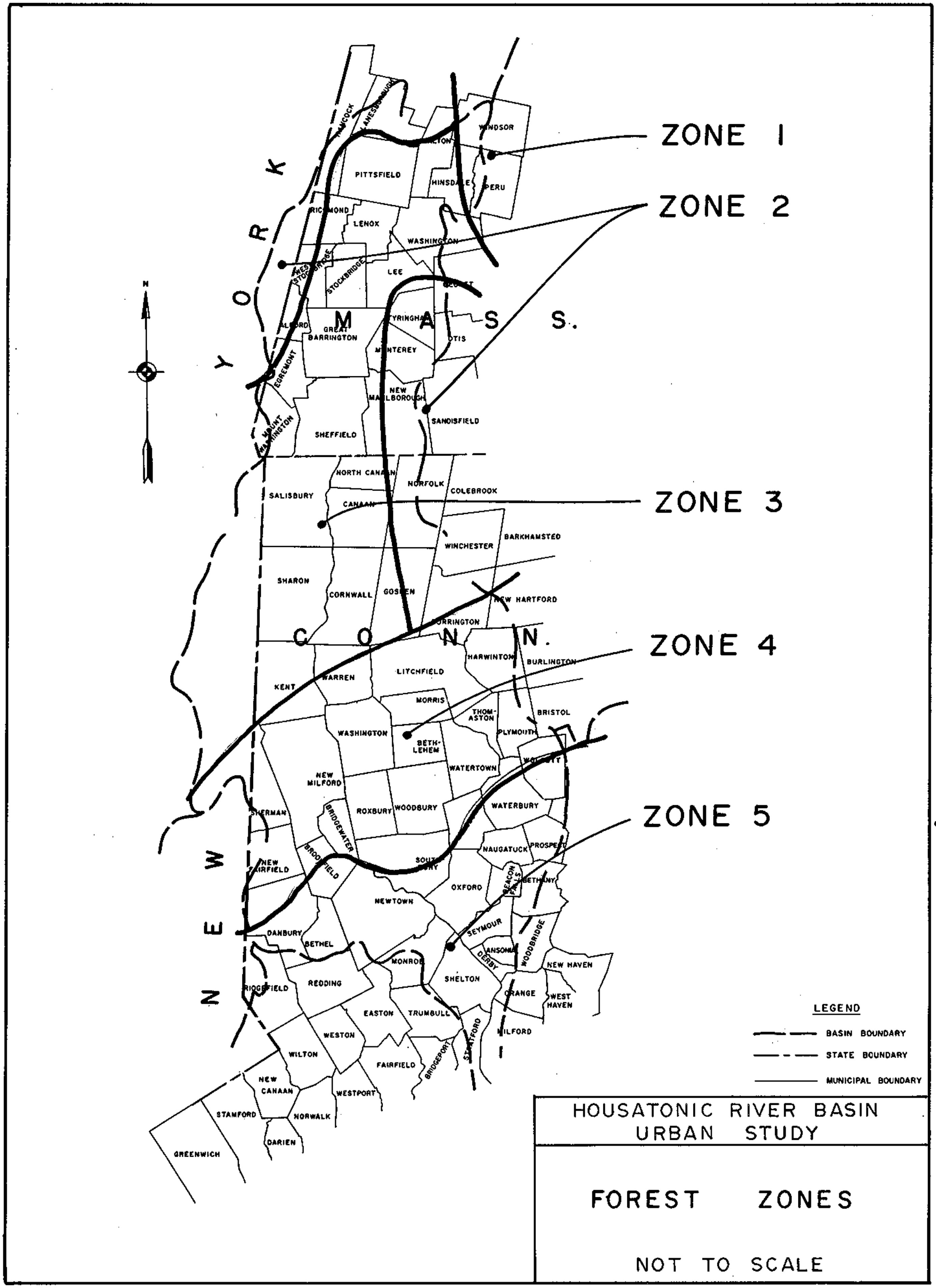
The Central Hardwoods-Hemlock-White Pine association (Zone 4) lies to the south of Zone 3. Central Hardwoods such as black, red and white oaks, chestnut, shagbark and bitternut hickories are more abundent than beech and birches. American chestnut was an important dominant species prior to the infamous blight of the the 1920's. This zone represents the southern limit of the white pine range and therefore eastern red cedar levels tend to dominant old fields.

The southern most portion of the basin including southwestern Connecticut is dominated by the Central Hardwoods-Hemlock association (Zone 5, Plate A-2). Dominant species resemble those listed in Zone 4 with the exception of white pine. Open forests and woodland along the coast shows extensive development of vines and shrubs such as cat briar, green briar, poison ivy, Japanese honeysuckle, and Asistic bittersweet (Dowhan and Craig, 1976). Old fields are dominated by eastern red cedar.

The second most common vegetative cover types in the basin are open fields, pastural lands, and current and abandoned agricultural land. They are generally interspersed with woodland and residential areas in rural areas of the basin. Many of the present meadows and woodland were originally forests cleared for agricultural purposes. Abandonment of the latter land use has allowed successive waves of plant communities to establish themselves. Field vegetation therefore varies from agriculturally-related plants such as timothy, orchard grass or clover in recently abandoned areas to open woodland or forests in older areas where secondary succession is more advanced. As previously mentioned, the primary pioneering species in old fields is red spruce in the northern sections of the basin, white pine in the central part of the basin, and red cedar in the southern part of the basin. Other common trees include gray birch, quaking aspen, wild and domestic apple. Dogwood, pasture juniper, multiflora rose, raspberry, blueberry, wild spirea, and strawberry are common shrubs. Crops and forage grown on current agriculture land includes silage corn, vegetables, alfalfa, timothy, red clover, bluegrass and tall fescue.

The third major vegetative cover type in the basin is the various wetlands associated with the mainstem, its tributaries and standing waters. Inland wetlands include marshes, swamps, bogs, wet meadows and seasonally flood flats. Tidal wetlands located near the mouth of the mainstem are generally in the form of Spartina salt marshes. Wetland soils range from the peat of salt marshes and bogs to the organic mineral soils of marshes and swamps. Soils are usually poorly drained and therefore anaerobic near the ground surface. Seasonally flooded flats are an exception when not inundated.

Vegetation of inland wetlands is variable depending on the stage of plant succession, the depth of water, and the period of inundation. Emergent marshes with their characteristic cattails, sedges, rushes, and grasses represent the earliest stage of wetland succession and are the most valuable for wildlife such as waterfowl in terms of food, cover, and



HOUSATONIC RIVER BASIN
URBAN STUDY

FOREST ZONES

NOT TO SCALE

nesting requirements. A later stage of plant succession brings pioneering shrubs which eventually form one of two general types of shrub swamps: (1) An alder-dogwood-willow association common on post agricultural lands and (2) sweet gale-ericad association typical in acidic soils similar to bogs (Jorgenson, 1979). Jorgenson suggests the latter may be a transitional stage between marshes and bogs. Bogs are the least common wetland type in the basin. They are more common in the northern New England and Canada where the climate is more favorable to this unique community. Typical vegetation includes a mat made chiefly of leatherleaf supporting a unique association of sedges, shrubs, sphagnum moss, and small trees which are tolerant to the characteristic acidic water. Wooded swamps considered a later stage of wetland succession are probably the most common wetland in the basin. Characteristic species include red maple, black ash, sweet gum with a variety of shrubs, mosses, ferns and liverworsts. Another wooded wetland type is the white cedar swamp. This wetland type typically succeeds bog areas and is more commonly found in coastal regions. Wet meadows are open grassy areas consisting of shrubs and trees. Soils are generally saturated except during summer when the water table is just below the ground surface. Grasses are generally dominant to sedges and rushes, which generally occur in the wetter areas of the meadow. Floodplains are fertile flat areas adjacent to rivers. These are commonly found in the northern part of the basin along the mainstem. Their soils are derived from alluvium deposited during flood stages of the river. Because of their sandy nature, they are generally well-drained but usually become saturated during the spring high waters. Typical vegetation includes flood-tolerant trees such as silver maple, American sycamore, American elm, white oak, pin oak and black willow and the shrubs, blackberried elder and silky dogwood.

Tidal marshes are found near the mouth of the mainstem, A variety of salt-tolerant emergent grasses are characteristic of this wetland type; salt cordgrass and salt marsh bogs are the most common.

A more comprehensive description of the wetland vegetation is available in Jorgenson (1979).

Wetlands in the basin serve four important functions: (1) Fish and wildlife habitat for a large variety of game and non-game species of birds, fishes and mammals; (2) Storage of floodwaters during peak flood stages or during tidal flooding; (3) Improvement of water quality by absorption and recycling of nutrients and acting as sediment traps; and (4) Protection of ground water which is often recharged by wetlands at the surface.

The majority of the inland wetlands are distributed in the upper part of the basin. Two significant tidal wetlands, Great Meadows, Stratford and Nell's Island, Milford, are located in the lower end of the basin.

The U.S. Fish and Wildlife Service is mapping wetland types according to their recently developed classification system (Cowardin et al. 1979) on a nationwide basis. Mapping of the Housatonic Basin is currently in progress.

Wildlife. The previously discussed upland and wetland environments provide habitat for a variety of wildlife species typical of the northeastern United States. Table A-2 presents a cursory list of typical and/or characteristic species of wildlife in forest, openland and wetland type of habitats. Species such as whitetail deer, raccoon and skunk commonly have a variety of habitats and therefore are listed in more than one habitat. Blackbear and bobcat are generally found in the more northern sections of the basin. Coyotes and timber rattlesnakes are also found in the Massachusetts portion of the basin as well as in northwestern Connecticut. A more complete list of species may be found at the end of this Appendix in the 5 July 1978 letter from the U.S. Fish and Wildlife Service.

The State fish and wildlife agencies allow hunting and trapping of selected species in season. Open seasons have been established for pheasant, ruffed grouse, grey squirrel, cottontail rabbit, snowshoe hare, raccoon, red and grey fox in both Massachusetts and Connecticut. In addition Massachusetts has designated seasons for bobcat, blackbear and whitetail deer. The latter is an especially popular game species with its sizeable herds in the upper portion of the basin. Deer hunting in Connecticut, on the other hand, is restricted to land owners on their own property. No open seasons have been designated for blackbear and bobcat in Connecticut, however, Connecticut does allow hunting for quail. Seasons for ducks, geese, coots, gallinules, rails woodcoot and snipe are annually designated by the U.S. Fish and Wildlife Service for each state. Trapping seasons for beaver, otter, muskrat, raccoon, mink, opposum, fox, skunk and weasel have been established by other states. Fisher and bobcats are also trapped in Massachusetts.

Both states stock pheasant in suitable habitats such as wildlife management areas and State forests. Wild turkeys are being restocked by both states although no open season has been established.

Table A-2
Typical and/or Characteristic Wildlife Species According to Habitat Type*

Habitat Type	Mammals	Birds	Reptiles, Amphibians
Forest (Includes hardwoods, softwoods and pines)	whitetail deer red squirrel grey squirrel Grey fox porcupine raccoon striped skunk fisher bobcat blackbear coyote snowshare hare (softwoods) mice shrews moles	ruffed grouse woodpeckers thrushes vireos warblers flycatchers red-tailed hawk black capped chicakadee nuthatches wild turkey woodcock	northern black racer eastern milksnake king snake spotted turtle wood turtle box turtle marbled salamander spotted salamander grey tree frog American toad
Open Land/Agricultural Land	whitetail deer woodchuck red fox eastern chipmunk eastern cottontail rabbit meadow vole starnose mole striped skunk eastern mole meadowjumping mouse	robin common grackle rock dove cardinal catbird pheasant mourning dove sparrows Coppers hawk redtail hawk redshoulder hawk screech owl quail ruffed grouse	garter snake ribbon snake green snake American toad brown snake

Wetlands	mink beaver raccoon muskrat otter whitetail deer grey fox shrews mice starnose mole	herons grebes Canada grouse common loon American coot ducks sandpiper gulls belted king fisher sparrows osprey tree swallows red-tailed hawk marsh hawk redwinged blackbird	snapping turtle painted turtle spotted turtle ribbon snake northern water snake spring peeper common newt green frog pickerel frog leopard frog wood frog American toad

*modified from USDA (1977) and Clark (1976).

Rare, Threatened and Endangered Species. There are two Federally listed threatened or endangered animal species which potentially occur within the basin: the bald eagle and the American peregrine falcon. The U.S. Fish and Wildlife Service has indicated that critical habitat for either species does not exist in the basin. Both potentially use the area as a flyway during their migrations. In addition to the Federally listed species, both States of Connecticut and Massachusetts maintain their own lists of State, local and rare species.

The Connecticut species are listed in Dowhan and Craig (1978). Massachusetts is currently in the process of compiling their lists. The "mammals" and "reptiles and amphibians" lists have been completed (Cardoza, 1979; Cardoza and Mirick, 1979). The rare bird list is maintained by the Massachusetts Audobon Society whereas the rare plant list is maintained by the Massachusetts Natural Heritage Program.

There are a number of unusual or critical habitat types in the Housatonic basin that are important for the survival of State, local or rare species. These include: Black spruce bogs; high summit habitat for uncommon boreal, appalachian or carolinean species; marble ridges, ledges, caves, and wetlands; marl lakes and ponds; flood plain forests, old growth forests; coastal sand beaches and salt marshes. Descriptions and examples of these habitat types may be found in Dowhan and Craig (1976) and USDA (1977).

Minerals

Sand, gravel and stone resources are excellent in the Housatonic Valley. In spite of increasing demand and product value, a major problem facing producers of crushed stone and sand and gravel is the foreclosure of potentially minable deposits by urbanization, increasing land values, and/or restrictive zoning. The necessity of locating such operations at the site of the deposit, often in river valleys, and near demand centers, such as developing areas, often creates conflicts with other land users and makes it economically infeasible or legally impossible to extract the resource. This problem is especially severe in southwestern Connecticut, and in the Pittsfield area.

In the town of Canaan, high grade dolomite has been quarried and used for production of calcium metal. This metal is used for the removal of impurities in steel making and the production of aluminum, magnesium, uranium, oxide and thorium. Agricultural limestone is also produced in significant quantities from this area.

Along the river there are several small sand and gravel pits and quarries. Most of these are less than 1/4 mile from the river. Peat is produced from one location in New York. Iron ore mines in northwestern Connecticut were important to the historical development of the region, but are no longer worked.

Water

Runoff. Approximately 50 percent of the annual runoff occurs during March, April, and May. The remaining runoff is distributed uniformly throughout the rest of the year, although the lowest streamflows generally occur in August. The average mean streamflow in the Massachusetts section of the basin is 1.72 cfs/sq. mi.; in New York and Connecticut the values range from 80 percent to 115 percent of the Connecticut statewide average of 1.80 cfs/sq. mi., generally increasing from west to east. Table A-3 presents flows from twelve of the sixteen long-term USGS stream gaging stations in the basin.

Runoff is also retained in approximately 407 lakes and ponds in the basin. Candlewood Lake is the largest lake having a surface area of 5,600 acres and 46,450 million gallons (mg) of usable storage. Other significant lakes are Lake Lillinonah (1900 acres, 13,135 mg), Lake Zoar (1053 acres, 2476 mg), and the Thomaston Dam flood control impoundment (950 acres, 13,690 mg). The two largest lakes in the Massachusetts section of the basin are Onota (617 acres) and Pontoosuc (467 acres).

Groundwater

In many areas sand and gravel aquifers are present and there appears to be substantial amounts of groundwater, especially where the aquifers include or are bordered by streams. The fact that high yield potentials exist in certain parts of the basin, however, does not necessarily imply that ample supplies of groundwater can be delivered on demand to need areas. Distance of transport and water quality considerations limit the availability of groundwater. Unfortunately, salt water intrusion and/or pollutants generated by increased urbanization have resulted in groundwater of substandard quality existing in several aquifers throughout the study area.

Groundwater aquifers, shown on Plate 2 in the Main Report of much of the study area have been investigated by the United States Geological Survey (USGS) and various agencies and firms in both States. Reports of these agencies and other hydrogeologic reports served as reference sources for the groundwater assessment included in Appendix C. The scope of the study did not allow for field exploration of field testing of estimated yields.

Water Supply

Within the water supply study area there are 146 water systems serving over 975,000 people in 61 communities. However, 67 of these systems, are located in the four communities surrounding Candlewood Lake and they supply water primarily during the summer recreation season. A listing of the water systems in each community are shown on table A-4. Following are discussions of the major water supply companies that are projected to experience supply problems in the future.

TABLE A-3
Streamflow at Selected Stations
(1914-1980)

Station	Subbasin	Drainage Area (sq. mi.)	Maximum cfs (year)	Average cfs (years of record)	7 day, 10 yr low cfs	Minimum daily cfs (year)	Remarks
1. E. Branch Housatonic R. at Coltsville	Upper MA Mainstem	57.1	6400 (1938)	116 (43)	18	4.4 (1936)	Flow regulated; upstream diversion; 7 day, 10 yr flow
2. Housatonic R. near Great Barrington	Upper MA Mainstem	280	12,200 (1949)	530 (66)	85	1.0 (1914)	Flow regulated; 7 day, 10 yr flow
3. Green R. near Great Barrington	Lower MA Mainstem	51	6400 (1938)	80 (16)		4.4 (1936)	
4. Housatonic R. at Falls Village	Upper CT Mainstem	634	23,900 (1949)	1092 (66)		24	Flow regulated
5. Tenmile R. near Gaylordsville	Tenmile	203	17,400 (1955)	305 (50)	11	7 (1957)	Infrequent regulation at low flow
6. Housatonic R. at Stevenson	Lower CT Mainstem	1541	75,800	2624 (5)	205		Practically no flow at times; regulated
7. Shepaug R. near Roxbury	Shepaug	133			6.3		
8. Pomperaug R. at Southbury	Pomperaug	75	29,400 (1955)	128 (47)	5.2	2.5	Flow regulated
9. Naugatuck R. at Thomaston	Upper Naugatuck	99.2	53,400 (1955)	203 (20)		8.4 (1964)	Flow regulated
10. Naugatuck R near Thomaston	Upper Naugatuck	71.9			14		

Station	Subbasin	Drainage Area (sq. mi.)	Maximum cfs (year)	Average cfs (years of record)	7 day, 10 yr low cfs	Minimum daily cfs (year)	Remarks
11. Naugatuck R. at Beacon Falls	Lower Naugatuck	259	106,000 (1955)	495 (57)		40 (1930)	Flow regulated
12. Naugatuck R. at Beacon Falls	Lower Naugatuck	261			59		Flow regulated

The investor-owned, Bridgeport Hydraulic Company is the largest water company in the study area. It serves 65 million gallons of water daily to over 360,000 people in 13 communities. There are 3 major surface water collection systems presently supplying the region. The Hemlock Reservoir Complex, which is the largest of the three systems, includes the Saugatuck, the Aspetuck and the Hemlock Reservoirs, which provide a safe yield of 34.5 mgd. The Easton Reservoir, which collects and stores the flow of the upper Mill River watershed, has a safe yield of 13.8 mgd. The Trap Falls Reservoir Complex which generally collects flow from the watershed of Far Mill River and its tributaries, provides a 7.3 mgd safe yield. Bridgeport Hydraulic also obtains water from 10 well fields. The two largest well fields are the Housatonic and the Westport. The Housatonic wells, which can presently supply a safe yield of 18 mgd, are located in Shelton. The Westport well field, located by the Saugatuck River in Westport, yields about 5 mgd. The total safe yield of the system is 76 mgd.

The Bethel Water Department, a community system, serves about 9000 people with an average 1.1 mgd of water. They obtain their supply from Chestnut Ridge Reservoir, Eureka Reservoir, Mountain Pond and the Maple Ave. wells. The total safe yield of these sources is 1.52 mgd. The town of Bethel also has another major water company, the investor-owned Bethel Consolidated Water Company. They own a well from which they maintain a .26 mgd safe yield. They presently serve about .075 mgd to about 1300 people.

The Danbury Water Department is by far the largest supplier of water within Danbury. They presently serve over one-half the population of the town. The water department maintains a safe yield of 10.6 mgd, from the Margerie Lake System, West Lake System and the Lake Kenosia well field. The Lake Kenosia well field is adjacent to the Jensen property, which has a well with traces of trichloroethane and tetrachloroethylene. The source of pollution is improper disposal of septage and/or industrial waste dumping. The source accounts for 2 mgd of the total safe yield. The water company presently provides over 7 mgd to the 35,000 people they serve.

The New Milford Water Company is a subsidiary of the investor-owned General Water Works. They provide about 1 mgd to the 5000 people they serve in New Milford. The 2.04 mgd safe yield is provided by a series of reservoirs and the Fort Hill wellfield. The reservoirs are experiencing turbidity and color problems and are being phased out in lieu of further development of the Fort Hill wellfield.

TABLE A-4
SUMMARY OF WATER SUPPLIERS - CONNECTICUT

TOWN	WATER COMPANY	POPULATION SERVED	(MGD) AVG. DAILY CONSUMP.	(MGD) SAFE YIELD S.W.	G.W.
Bethlehem	North Purchase Supply	48	.0036		.004
Middlebury	Hillcrest Fire District	576			
	Westover Water Co. (Westover School)	450	.034	0	.13
Naugatuck	Naugatuck Division CT Water Co.	21,960	3.7	4.77	0
Oxford	Bridgeport Hydraulic Co.	210			
Prospect	Highland Heights	102	.007	0	.01
	Harmony Acres M.H.P.	395	.029	0	.07
Southbury	Southbury Training School	2,450	.325	0	.40
	Heritage Village	4,100	1.0	0	2.0
	Southbury Building Supply	38	.002	0	NA
	Lakeside Water	388	.032	0	.40
Thomaston	Thomaston Division CT Water Co.	3,310	.6	.40	.65
Waterbury	Waterbury Water Dept.	103,000	16.4	28.3	0
	Naugatuck Division CT Water Co.	230		(see Naugatuck)	
Watertown	Watertown Water and Sewer Authority	13,179	.935	(See Waterbury WD)	
	Watertown Fire Distr.	6,310	.828	0	2.5
Wolcott	Lake Hills Village	84	.004	0	.022
	Alma Properties	24	.002	0	.003
Woodbury	Woodbury Water Co.	1,600	.13	.69	.11
	Town & Country Apts.	320	.024	0	.081
	Woodbury Village	700	.048	0	.189
	Quassak Heights Apt.	95	.007	0	.021
	Swiss Village	258	.019	0	.027
	Heritage Apts.	136	.01	0	.032
Bridgeport	Bridgeport Hydraulic Co.	142,546	65.5	56	20

TABLE 4 (Cont.)

TOWN	WATER COMPANY	POPULATION SERVED	(MGD) AVG. DAILY CONSUMP.	(MGD) SAFE YIELD S.W.	G.W.
Easton	Bridgeport Hydraulic Co.	2,130			
Fairfield	Bridgeport Hydraulic Co.	54,699			
Monroe	Bridgeport Hydraulic Co.	5,300			
Stratford	Bridgeport Hydraulic Co.	50,533			
Trumbull	Bridgeport Hydraulic Co.	33,011			
Bethel	Bethel Water Dept.	10,400	1.1	.66	.86
	Bethel Consolidated Water	1,325	.075	0	.026
	Chestnut Hill	256	.019	0	.019
Bridgewater	None	0			
Brookfield	Brookwood	300	.023	0	.07
	Arrowhead Point	260	.02	0	.042
	Brook Acres	200	.015	0	.038
	Butternut Ridge	128	.008	0	.045
	Candlewood Acres	120	.009	0	.049
	Candlewood Shores	746	.075	0	.26
	Cedar Brook Apts.	124	.009	0	.03
	Hickory Hills	125	.009	0	.018
	Indian Fields	112	.008	0	.037
	Silver Mine Manor	100	.008	0	.032
	Wisconeer Apts.	160			
Danbury	Danbury Water Dept.	40,000	7.2	8.6	2.06
	Briar Ridge	276	.021	0	.029
	Aqua Vista	280	.021	0	.053
	Racing Brook Meadows	327	.024	0	.065
	Cedar Heights	440	.023	0	.032
	Clap Board Ridge	132	.009	0	.043
	Hawthorne Terrace	108	.008	0	.054
	Indian Spring	356	.029	0	.108
	Ken Oakes	128	.006	0	.032
	Hollendale Estates	284	.021	0	.025
	Rolling Ridge	160	.012	0	NA
	Middle River	276	.019	0	.064
	Pearce Manor	128	.010	0	.055

TABLE 4 (Cont.)

TOWN	WATER COMPANY	POPULATION SERVED	(MGD) AVG. DAILY CONSUMP.	(MGD) SAFE YIELD S.W.	G.W.
Danbury (Cont.)	Pleasant Acres	566	.037	0	.025
	Ridgebury Estates	340	.026	0	.105
	Ridgeview Gardens	108	.005	0	.025
	Sherwood Forest	166	.010	0	.046
	Snug Harbour	144	.011	0	.032
	Waubeek Lake	1012	.073	0	.216
	Willow Run	164	.009	0	.027
	Ta'Agen Point	56	.002	0	.001
	High Acres M.H.P.	21	.003		NA
	Cedar Terrace P.D.A.	68	.005	0	.005
	Pocono Pt.	40	.003	0	.013
	Cornell Hills	100	.007	0	.024
	Cedars	16	.001	0	.001
Harwinton	None	0			
Litchfield	Litchfield Division Litchfield County Water Co.	2,270	.26	0	.480
	Bantam Properties	240	.018	0	.038
Morris	None	0			
Norfolk	Norfolk Division Litchfield County Water Co.	1,530	.252	.51	0
Torrington	Torrington Water Co.	20,760	3.88	4.72	.06
Canaan	Canaan Water Co.	250	.02	0	.03
Cornwall	Cornwall Division Litchfield County Water Co.	220	.022	0	.03
Kent	Kent Water Co.	1,000	.068	.124	.141
	Kent Boys School	500	.06	0	.081
	Kent Girls School	250	.018	0	.038
North Canaan	North Canaan Division Litchfield County Water Co.	1,930	.325	.005	.53
Roxbury	None	0			

TABLE 4 (Cont.)

TOWN	WATER COMPANY	POPULATION SERVED	(MGD) AVG. DAILY CONSUMP.	(MGD) SAFE YIELD S.W.	G.W.
Salisbury	Salisbury Division Litchfield County Water Co.	3,070	.34	.320	.32
Sharon	Sharon Water and Sewer Commission	700	.205	.39	0
Warren	Hopkins Supply	36	.003	0	ADEQ
	Arrow Point Water Co.	200	.015	0	.162
Washington	Bryan Memorial	180	.014	0	.11
	Judea Water Co.	425	.025	0	.022
	New Preston Water Co.	88	.007	0	.021
	Bee Brook Crossing	30	.002	0	.043
	Wykeham Rise	100	.005	0	NA
	The Gunnery	225	.011	0	.032
Darien	Noroton Division CT American Water Co.	16,059	2.1	Stamford	W.C.
Greenwich	Greenwich Division CT American Water Co.	59,578	16.7	17.0	0
New Canaan	New Canaan Water Co.	9,860	1.06	.7	.67
Norwalk	1st Taxing District	42,000	5.92	2.5	3.5
	2nd Taxing District	35,767	5.1	4.5	0
Stamford	Stamford Water Co.	84,525	16.76	19.0	0
Weston	Bridgeport Hydraulic Co.	250			
Beacon Falls	Bridgeport Hydrualic Co.	1,558	.26		
	Ansonia-Derby Water Co.	200	.034		
New Fairfield	Timber Trails	38	.003	0	.010
	Ball Pond Estates	700	.039	0	.094
	Fieldstone Ridge	108	.005	0	.022
	Oakwood Acres	380	.026	0	.032
	Possum Ridge	276	.016	0	.086
	Candlewood Knolls	404	.036	0	.086
	Knollcrest	340	.026	0	.107

TABLE 4 (Cont.)

TOWN	WATER COMPANY	POPULATION SERVED	(MGD) AVG. DAILY CONSUMP.	(MGD) SAFE YIELD S.W.	G.W.
New Milford	New Milford Water Co	5,820	1.12	.964	1.08
	Arrowhead Apts.	136	.01	0	.081
	Lords M.H.P.	280	.015	0	NA
	Camelot Estates	620	.03	0	.068
	Candlewood Lake Apts.	216	.016	0	.021
	Parkwood Acres	160	.012	0	.016
	Candlewood Springs	120	.009	0	.017
	Candlewood Terrace	230	.017	0	.072
	Candlewood Trails	320	.024	0	.068
	Har Bil Water Co.	224	.010	0	.058
	Indian Ridge	208	.009	0	.091
	Lillinonah Park Estates	120	.006	0	.032
	Millstone Ridge	225	.017	0	.081
	Lone Oak	270	.01	0	.038
	New Milford Hgts.	400	.030	0	.065
	Hi-Vu Water Co.	104	.006	0	.032
	Hawthorne East Apts.	157	.012	0	.162
	Dean Heights	224	.017	0	.065
	Millbrook Water	510	.027	0	.185
	Old Farms Apt.	250	.013	0	.023
Newtown	Newtown Water Co.	3,240	.31	.50	0
	Fairfield Hills Hospital	2,076	.376	0	1.84
	Lake Zoar (Olmstead Supply)	272	.007	0	.019
	Chestnut Tree Hill	192	.012	0	.07
	Meadow Terrace (M.H.P.)	240	NA	NA	NA
Redding	Gilbert and Bennett	430	.012	0	NA
Ridgefield	Ridgefield Water Supply	13,000	.75	0	.77
	Ridgefield Knolls	1,100	.075	0	.154
	Soundview	128	.008	0	.016
	Hemlock Hills	176	.010	0	.055
	Craigmoor	60	.004	0	.010
	Ridgefield Lakes	674	.054	0	.111
	Brookview	92	.007	0	.016
Sherman	Timber Trails	500	.028	0	.101
	Holiday Point	160	.012	0	.108
Westport	Bridgeport Hydraulic Co.	24,300			
Wilton	Bridgeport Hydraulic Co.	770			

TABLE 4 (Cont.)

TOWN	WATER COMPANY	POPULATION SERVED	(MGD) AVG. DAILY CONSUMP.	(MGD) SAFE YIELD S.W.	G.W.
Ansonia	Ansonia-Derby Water Co.	18,841	5.64	3.6	3.1
Derby	Ansonia-Derby Water Co.	12,184			
Seymour	Ansonia-Derby Water Co.	1,220			
	Bridgeport Hydraulic Co.	7,740			
Shelton	Bridgeport Hydraulic Co.	20,100			
	MASSACHUSETTS				
Dalton	Dalton Fire District	5,642	1.5	2.96	
	New Junction Water Co.	750	.06		.07
Egremont	S. Egremont Water Co.	833	.155	.19	
Great Barrington	Gt. Barrington Fire District	3,500	1.03		2.68
	Housatonic Water Works	2,700	.28		.6
Lanesborough	Lanesborough Village Fire and Water	2,400	.205		.864
Lee	Lee Water Dept.	6,500	1.42	1.14	
Lenox	Lenox Water Dept.	6,000	.8	.64	
Monterey	Monterey Water Co.	200	.013	.02	.07
New Marlborough	Mill River	100	.006	.01	
	Southfield Water Trust	120	.007		.029
Pittsfield	Pittsfield Water Co.	57,690	14.7	14.7	
Richmond	Gilchrist Springs	40	.002		.05
Sheffield	Sheffield Water Dept.	1,242	.074		.2
Stockbridge	Stockbridge Water Dept.	1,900	.4	.4	
	Mahkeenac Water Works Co.	255	.015		.043
	Hill Water Co.	100	.005		.02
West Stockbridge	W. Stockbridge Water Co.	1,000	.06	.25	

The Newtown Water Company is also a subsidiary of General Water Works. They serve a little over 3,000 people within Newtown with an average of .31 million gallons daily. Their only source of supply is Taunton Lake which provides a safe yield of .5 mgd. They are presently investigating the possibility of developing groundwater supplies to replace Taunton Lake, which is experiencing turbidity and color problems.

The Ridgefield Water Company serves 13,000 people in the town. Their sources of supply consist of the Round Pond Reservoir with a safe yield of .77 mgd and the Osceletta wells with a safe yield of .66 mgd. Because of color, odor and turbidity problems, the water company has been ordered by the DOHS to shut-down their Round Pond Reservoir. This action causes their average day demand and safe yield to be about equal.

The New Canaan Water Company, a private purveyor, serves about 10,000 people an average of 1.06 mgd. The water company is supplied by the New Canaan Reservoir which has a safe yield of .7 mgd and a well system with a 1.242 mgd safe yield. But the Nature Center and Lloyd wells are high in manganese and iron and are only used in emergency situations. Also the Weeks Street well cannot be used if the level in the stream is too low. Without these sources, the total safe yield is only 1.37 mgd.

The Stamford Water Company is an investor-owned company serving over 82,000 people in Stamford. They also supply one mgd to the Noroton Division of the Connecticut American Water Company serving about 20,000 people in Darien. The entire supply comes from a 5 reservoir system providing a safe yield of 17.5 mgd. The present treatment capacity is less than 17.5 mgd, but an addition is being made on one of the treatment plants to increase capacity.

The Norwalk Second District Water Department serves about 35,000 residents in southwestern Norwalk. Their source of supply is from 4 reservoirs with a total safe yield of 4.5 mgd, which is less than their average day usage of 5.1 mgd. They are also interconnected with the Bridgeport Hydraulic Company via a 24-inch main. They can purchase up to 3 mgd of water from Bridgeport to augment their supply. They presently sell one mgd to the Norton System in Darien.

The Norwalk First District Water Department supplies about 42,000 residents in the city not served by the Second District Department. The First District obtains its normal supply from both surface water and wells. There are 4 reservoirs in series collecting runoff from 10.5 square miles of the Silvermine River watershed. The groundwater is provided by the Deering Pond well field. This source has a safe yield of 3.5 mgd, which when added to the surface water, provides a combined safe yield of about 6 mgd. The water department presently serves 5.9 million gallons daily to its customers.

The Greenwich Division, a subsidiary of Connecticut American Water Company, supplies water to the town of Greenwich, Connecticut and to the Port Chester Water Works, Inc. also a subsidiary in New York. The Greenwich Division supply system consists of the Bargh, Putnam, Brush and Rocklake Reservoirs having a safe yield of 17 mgd. The total demand, at present, including Greenwich and Port Chester Water Works, is about 16.8 mgd. The Greenwich Division presently has a 75-year contract with Port Chester Water Works signed in 1954, saying that Port Chester could buy approximately 50 percent, but not more than 8 mgd, of Greenwich's available water supplies. Approximately, 4 mgd is presently sold by Greenwich.

The Pittsfield Water Department in Massachusetts serves all of Pittsfield's 52,000 residents. The average daily usage by the customers is 12.5 mgd. The entire water supply of the City of Pittsfield is derived from surface water impoundments in the towns of Dalton, Washington, and Hinsdale. The existing safe yield of the reservoirs is 14.7 mgd. The Pittsfield Water Department also has a contract to sell up to 1.5 mgd to Dalton.

Water Quality

Stream Quality. Five river segments in the Housatonic basin are currently not meeting the fishable-swimmable goals of the Clean Water Act of 1977: the upper Housatonic River in Massachusetts (38 miles), the lower Housatonic in Connecticut (51 miles), the Naugatuck River (15 miles), the Still River (21 miles) and portions of the Tenmile River and its tributaries in New York. The primary reason for this designation is the polychlorinated biphenyl (PCB) concentrations in the sediments and fish. More specific information on pollution sources is discussed in the following section. If PCB-contaminated water is defined as non-fishable, then 109 miles of the Housatonic will not meet the 1983 fishable-swimmable goals. These segments are further described in Table A-5.

Pollution Sources. A major pollution problem in the Housatonic from Pittsfield to and including Lake Zoar is the presence of high levels of toxic PCB compounds which were discharged primarily from the General Electric plant in Pittsfield from the early 1930s until 1977, and now continue to enter the environment from landfills, runoff and sediments. Since these compounds have low solubility, they do not significantly affect water quality. However, they have become concentrated in fine-grained bottom sediments and fish tissue at levels much higher than the maximum tolerance level set by the Food and Drug Administration. As a result, both Massachusetts and Connecticut have issued public health warnings against the consumption of fish taken from the river, and the Connecticut DEP has temporarily downgraded its classification of that section of the river from a B_S to a D.

A second pervasive problem in the river, particularly in the run-of-the-river lakes such as Woods Pond in Massachusetts and Lakes Lillinonah, Zoar, and Housatonic in Connecticut, is high nutrient levels (principally phosphorus) and the resulting eutrophication from numerous nonpoint and point sources including the wastewater treatment plants at Wassaic State School, Pittsfield and Harlem Valley Hospital in New York (both State-owned institutions), and Danbury, Bethel, and New Milford, Connecticut. Various studies and analyses conducted by the Connecticut Agricultural Experiment Station, Connecticut DEP, the EPA National Eutrophication Survey, and others indicate that 30 percent of the total phosphorus load on Lake Lillinonah comes from Danbury, 28 percent from Massachusetts (primarily Pittsfield), and 15 percent from New York. Although eutrophication of the three lakes in Connecticut will probably always be a problem due to the large size of the watershed (over 1,000 square miles) and numerous nonpoint sources, the results of temporary phosphorous removal at the Danbury plant in 1976 and 1977 and at Pittsfield in 1978 indiate that control of these sources can substantially reduce the total load on the lakes and change the character of algal blooms.

The Housatonic River in Massachusetts is subject to low dissolved oxygen and high coliform levels due to industrial and municipal discharges, combined sewer overflows, and urban runoff. Two major industrial sources --Crane Paper and General Electric -- discharge into the low flowing East Branch of the Housatonic. Neither plant has completed the application of Best Practicable Treatment needed to meet 1977 interim water quality goals, and both (along with another downstream discharge) will need Best Available Technology to meet the 1983 goals. Pittsfield municipal sewage treatment plant discharges violate coliform and phosphorus standards, and urban runoff from Pittsfield causes coliform violations about 18 percent of the year. Combined sewer overflows from Great Barrington are also problematic, estimated to be two million gallons for a typical storm event that would be expected to occur forty times per year.

The Still River's waste assimilation capabilities are severely taxed by the large volume of industrial (primarily metal-finishing) and municipal discharges in the Danbury area. This region is expanding rapidly and, according to a recent DEP report, new growth will have to be serviced by subsurface disposal systems within 10 to 20 years.

The Upper and Lower Naugatuck subbasins have historically suffered the most severe water quality problems in the basin, due to the high degree of residential and industrial development. Municipal problems include infiltration/inflow excesses in six towns, combined sewer overflows in Waterbury and Derby (a recent estimated cost of correction was $804,000 in Derby and $3,300,000 in Waterbury), operational problems at one of Watertown's plants and inefficient operation of the Waterbury plant due to the large volume of industrial discharges to the sanitary sewers. Most of these problems are being addressed by needs surveys or Section 201 facilities planning studies.

TABLE A-5: WATER QUALITY PROBLEM AREAS

Subbasin/River/Location	Water Quality Problems STP = Sewage Treatment Plant BOD = Biological Oxygen Demand
HOUSATONIC MAIN STEM (ALL)	
Housatonic River	
Pittsfield to Stevenson Dam	Toxic PCBs in fish and bottom sediments, high phosphorus from Pittsfield STP and nonpoint sources
UPPER MA HOUSATONIC MAIN STEM	
East Branch Housatonic and Main Stem	
Dalton to Lee	Low dissolved oxygen and high coliform levels from industries and Pittsfield, North Lenox STP; aggravated by low flows in upper reaches and Woods Pond sink.
Housatonic River	
Stockbridge to Great Barrington	High coliform levels from Stockbridge STP.
LOWER MA HOUSATONIC MAIN STEM	
Housatonic River	
Hubbard Brook and Housatonic River in Sheffield	High coliform levels from domestic raw sewage and septic systems.
TENMILE	
Tenmile River	
Wassaic State School to Indeterminate Point Downstream	High phosphorous and BOD from overloaded STP.
Swamp River	
Pawling to Tenmile River	High BOD from overloaded STP at Pawling; high phosphorous from Harlem Valley Psychiatric Center STP.
MIDDLE CT HOUSATONIC MAIN STEM	
Still River	
Sympaug Brook Confluence to Mouth	Phosphorous and low dissolved oxygen from Danbury and Bethel STPs.
Housatonic River	
Lake Lillinonah	Eutrophication caused by excessive phosphorus from upstream sources, PCBs in sediments and fish.

TABLE A-5 (Cont.)

<u>SHEPAUG</u>	
Bantam Lake	Eutrophication, rooted vegetation; high nutrient levels in bottom sediments.
<u>UPPER AND LOWER NAUGATUCK</u>	
<u>Naugatuck River</u>	
Torrington STP to Mouth	High amonia, total organic carbon, BOD_5, phosphorous, iron, copper, zinc, low dissolved oxygen from numerous sources, high coliforms from urban runoff and combined sewer overflows in Waterbury, Derby, and Ansonia.
<u>LOWER CT HOUSATONIC MAIN STEM</u>	
<u>Housatonic River</u>	
Lakes Zoar and Housatonic	Eutrophication caused by excessive phosphorus from upstream sources, PCBs in sediments and fish.
Naugatuck River Confluence to Merrit Parkway Bridge	High coliform counts from combined sewer overflows at Shelton and Derby; municipal and industrial discharges.

In addition to municipal discharges, wastes from 48 significant (greater than 20,000 gpd) industrial discharges must be assimilated by the Naugatuck River and its tributaries. Specific problems occur during low flows in Long Swamp Brook, due to treated metal finishing wastes; in the Mad River, from treated industrial discharges and thermal loadings; and in the Naugatuck River, where industrial discharges to the Derby municipal sewerage treatment plant (STPs) are causing operational problems. The implementation of a water quality permit program has improved the river considerably in recent years.

High coliform counts are the major water quality problem in the lower Housatonic River below Derby, and are caused by combined sewer overflows at Shelton and Derby. Three of the four municipal STPs in Milford are overloaded or obsolete, and the town is currently planning for facility expansion that may include eliminating the current discharges to the Gulf Pond Estuary and Milford Harbor.

Lake and Pond Quality. In Massachusetts, 13 lakes were surveyed by DEQE, and of these, the Berkshire County Regional Planning Commission studied 11 as part of the 208 process. The results showed that Woods Pond (a run-of-the-river impoundment) was eutrophic, and that Stockbridge Bowl, Lake Buel, Laurel Lake, and Pontoosuc Lake were approaching that condition. All of these lakes have moderate to dense development (leisure homes) and recreational use. The problem is significant from a regional standpoint because of the importance of these lakes to the tourist industry and to property tax bases. Recommended control measures include sewering some of the lakeside development as well as in-lake measures and land use management.

In Connecticut, 29 lakes have been identified by DEP as having water quality problems. Nine of these and two additional ones have also been studied by the Connecticut Agricultural Experiment Station at New Haven as part of the state's Lake Management Program. Lakes Lillinonah and Zoar were classified as highly eutrophic, and Bantam, Waramaug, and Wononskopomuc were found to be eutrophic. No lakes in the New York portion of the basin are believed to have a significant enough problem to warrant eutrophication study.

Ground Water Quality. In Massachusetts, the 208 study identified 13 "priority aquifers" for water supply and inferred threats to their quality in primary and secondary recharge areas. Of the 13, eight have a moderate threat from landfills, mining, urbanization, or highways and three have major threats from landfills or sewage treatment plants. As protection efforts, the 208 study recommended ground water protection use guidelines based on the density of residential development, and the evaluation and control of individual threats. The threat of ground water contamination by PCBs in aquifers adjacent to the Housatonic River has not been fully evaluated to date. The USGS was in the process of drilling test wells along the Housatonic River between the river and high production wells that have been in operation for some time. They hope to determine the existing concentrations of PCBs, if any, in the aquifer and the rate of movement through the aquifer. They were investigating two separate aquifers and the studies were scheduled for completion in September 1982. The studies have not been completed due to lack of funding.

In Connecticut, the USGS has published a series of statewide maps showing existing and potential ground water contamination sources and their relationship to major aquifers, including:

- Disposal of Solid Wastes;
- Industrial Areas and Ground Disposal of Industrial Wastes;
- Non-sewered Built Up Areas and Septage Disposal Sites;
- Surface Water Quality and Built Up Areas;
- Road Salt Storage and Road Network;
- Pipelines and Storage Facilitiees for Gas and Oil*;
- Agricultural Areas and Manure Storage*;
- Ground Water Sources Exhibiting Impaired Water Quality*.

*soon to be published

Analysis of this information indicates that:

. ground water contamination of favorable aquifers by Department of Transportation salt storage piles is a problem in Kent, Watertown, and Southbury, as well as in Thomaston and Naugatuck since both communities used 10 or more tons of salt per road mile.

. documented ground water contamination from solid waste disposal sites occurs in Watertown, Naugatuck, Monroe, Beacon Falls, and Milford;

. ground water contamination from industrial waste ground disposal or accidental spills occurs in Bethel, Newtown, and Stratford.

Other Nonpoint Source Problems. Many of the nonpoint sources of pollution mentioned in the preceeding paragraphs also affect surface waters. In some cases, as with landfills, water quality impacts can be documented and regulatory orders can be issued to control or eliminate the problem. However, in most instances water quality impacts of identified sources have not been fully quantified, as with lake eutrophication, or the sources themselves have not been accurately located, as with many failing septic systems.

CULTURAL RESOURCES

Analysis of soil data indicates that the formation of the Housatonic Valley occured approximately 12,000 years ago with the recession of the last ice sheet.

The first recorded evidences of man's appearance in the valley date back to the early 17th century. The first inhabitants of this region are believed to have been members of the Mohican family of the great Algonquin race. These Indians migrated to this area because they had been forced out of the Hudson Valley. In the late 17th century, nine tribes of Indians lived in the lower Housatonic Valley, which includes the portion of the basin in Connecticut, and only one tribe in the Upper Housatonic Valley, which comprises the Massachusetts portion of the basin. The Upper Housatonic tribe was originally called the Wusadenuk (Beyond-the-Mountain-Place). This name after many misspellings developed into Housatonuck and finally Housatonic.

The Housatonic River basin was first settled by English puritans who established the town of Stratford at the mouth of the river in 1639. Gradually the central portion of the basin was settled and Litchfield County was formed in 1751. Life of the colonists in this inland region was based on agriculture for which they cleared thousands of acres of forests. By 1796, Litchfield County contained 283,000 acres in farm land and 45,600 acres tilled for crops, which together accounted for 54.7% of the land in the county. Early settlements were founded in the towns of New Milford and Woodbury where grist mills, sawmills, tanneries, blacksmiths and other small businesses typically developed. Other small towns developed and prospered along the river since waterways were the primary arteries of transportation.

The first settlement by the white man in the Massachusetts portion of the Housatonic Basin occurred near the Housatonic Indian village in Stockbridge (1690-1700). The period of time following the white man's entrance into the valley is referred to as the Christianity Era. During this period daily life revolved around the church. In 1724 the territory surrounding Stockbridge, which comprises one quarter of Berkshire County, was bought from Chief Konkapot of the Housatonic Indians for 460 English pounds, three barrels of hard cider, and thirty quarts of rum. Later in the century, the Indians of the county lost the remaining land to the white man in a similar manner.

In the early 19th century, the natural resources of the valley were discovered and moves were made to exploit these findings. The major resources included iron ore, marble, limestone, and excellent water power. Foundries for the processing of the iron ore sprang up around rich deposits. The grade of iron ore being mined in the basin was said to be one of the finest in the world. The marble and limestone quarries produced a product so highly valued that it was used in the construction of Saint Patrick's Cathedral in New York City, the City Hall in Philadelphia, and the extension to the Capitol Building in Washington.

Another industry which grew alongside the iron and quarry operations and fared far better than either of them was the paper industry. As early as 1801, Wiswall, Crane, and Willard built the first mills along the East Branch in Dalton. Dalton, along with Lee, are the two towns in the basin most noted for their paper mills. Early in the 19th century, Crane Paper Company of Dalton received a contract from the United States Government for currency paper, a contract it still holds today. By 1840, Lee was producing one-fifth of the country's paper with a high of 25 operating mills in 1857.

The 19th century also brought great improvements in transportation through the development of railroads and highways. The Berkshire railroad was built during this time to connect the southern industrial centers of the basin with Pittsfield in the north. Several railroad stations and depots remain in their original condition along this line and are recognized by the State for their historical value.

Today, the influence of these colonial and industrial periods in the valley's history are evident not only in the historical buildings, bridges and iron furnaces, but also in the area's agricultural economy. These elements, together with the valley's scenic natural conditions and rural settlement pattern, create the historical colonial charm of this part of New England.

SOCIO-ECONOMIC PROFILE

The Housatonic River Basin lies principally in the western part of Connecticut and the southwestern corner of Massachusetts with a small portion extending into eastern New York. It comprises an area of 1,950 square miles; 1,232 in Connecticut, 500 in Massachusetts and 218 in New York. The study area, limited to the areas within Connecticut and Massachusetts includes the upper middle and lower portions of the Housatonic Basin, the major tributaries including the Naugatuck, Shepaug, Pomperaug and Still Rivers, and the southwestern portion of Connecticut which has been added to the study because of the major impact of its potential demands on the basin's resources. This profile will examine the land use, employment and population of the area in the hope of defining areas of potential growth which can be correlated with the water supply needs.

Land Use Information

The best available land use data is that provided by the regional planning agencies of Connecticut and Massachusetts. Data from the following agencies was used in its entirety: Northwestern Connecticut Regional Planning Agency, Central Naugatuck Valley Regional Planning Agency, Housatonic Valley Council of Elected Officials, Valley Regional Planning Agency, South Western Regional Planning Agency, and Greater Bridgeport Regional Planning Agency. Central Connecticut Regional Planning Agency's information was used just in regard to the community of Plymouth and the Berkshire County Regional Planning Commision data was used only concerning the 19 communities within the basin boundaries.

Of the total acreage, the majority, by far, has been classified as open/woodland area. The residential acreage is the next largest classification with over 17 percent of the land. More development has been occurring outside of the metropolitan areas in the suburbs than in the central cities. Growth is expected to continue in residential acreage using land currently undeveloped. In the Massachusetts portion of the basin, industrial and commercial growth increased by 68% in the period of 1952-1972. This trend is expected to continue due to the existence of the Massachusetts Turnpike, a major transportation route. However, it is unlikely that heavy industry will grow because of the environmental problems associated with this growth. In Connecticut, land once used for farmland will gradually be converted to residential, manufacturing and commercial uses. The Waterbury Labor Market Area, one of the largest in the state of Connecticut, has maintained a lower than average wage rate (compared to the State) which should stimulate some manufacturing growth there.

Employment and Labor Force

The major employment sector in the region is manufacturing, employing almost 37 percent of the basin's labor force as seen in Table A-6. Most of the manufacturing takes place along the Naugatuck and Housatonic Rivers where water-using manufacturers can take advantage of the resources available. More than 40 percent of the labor force in the Naugatuck and Lower Housatonic Valleys is employed in manufacturing, where as only 20 - 30 percent of the more rural areas' labor forces are employed in such industries. In Massachusetts, 50 percent of the manufacturing employment was in electrical machinery, equipment, and supplies, reflecting General Electric's role as the largest employer there.

However, there has been a slowdown in the growth of the manufacturing industry, in regards to employment, which is expected to continue in the future. This has and will result in the shifting of the labor force into the wholesale/retail and the services (personal, recreation, health) industries with 21.6 and 19.6 percent of the labor force employed respectively. The services industry has been growing rapidly and is expected to continue to do so. The 40 percent growth of these two industires from 1960 to 1970 in the Connecticut portion of the basin was higher than the State average and is somewhat indicative of future growth patterns. It is projected, however, that the wholesale/retail industry will be declining slightly over the next 30 years. Table A-7 projects, not in terms of labor force but by the contribution the industry makes to total earnings, the growth and decline of certain industries in the region.

The Housatonic River Basin has experienced unemployment rates consistent with, and on the average, lower than the State and national levels (See Table A-8). The planning area of Torrington, Connecticut had the highest level of unemployment, 6.7%, while the Norwalk, Connecticut area maintained the lowest rate in the basin of 4.0%. The smallest growth in employment, 9 percent, occurred in Berkshire County, Massachusetts in the northern part of the basin and was below both State and basin averages.

TABLE A-6
LABOR FORCE BY INDUSTRIAL SECTOR

INDUSTRIAL SECTOR	PERCENT OF LABOR FORCE
Agriculture	.2
Construction	2.9
Manufacturing	36.6
Transportation/communications Utilities	3.9
Wholesale & Retail	21.6
Finance, Insurance & Real Estate	3.9
Services	19.6
Government	11.3
TOTAL	100.0

Source: Connecticut Labor Market Reviews Feb 81. Employment & Wages for Cities & Towns, Massachusetts

TABLE A-7

PERCENT CONTRIBUTION OF REGION'S INDUSTRIES

TO TOTAL EARNINGS(1)

Sector	1950	1970	1990	2020
Agriculture, Forestry and Fishing	3.77 (9.11)	1.31 (3.49)	0.66 (1.96)	0.34 (1.10)
Mining	0.09 (1.99	0.12 (1.00)	0.09 (0.62)	0.06 (0.37)
Contract Construction	5.24 (5.97)	7.00 (6.13)	6.40 (6.06)	5.74 (5.53)
Manufacturing	45.63 (29.02)	36.89 (27.79)	28.12 (24.78)	21.45 (21.39)
Transport, Communication & Public Utilities	5.36 (8.17)	5.06 (7.10)	5.46 (6.90)	5.55 (6.68)
Wholesale & Retail Trade	15.37 (18.94)	14.52 (16.55)	13.75 (15.22)	12.42 (13.65)
Services	10.08 (11.18)	14.74 (15.13)	22.15 (19.94)	28.58 (23.49)
Personal Services	-- --	10.51 (9.28)	17.37 (13.75)	-- (17.51)
Government	9.07 (11.39)	12.70 (17.66)	15.24 (18.37)	23.02 (19.97)
Finance, Insurance & Real Estate	5.39 (4.23)	6.66 (5.14)	8.12 (6.15)	8.96 (6.81)

(1) OBERS Projections, 1972, Series E

Figures in parentheses are percent of United States Values.

TABLE A-8

LABOR FORCE & UNEMPLOYMENT DATA
HOUSATONIC RIVER BASIN

Planning Area	Labor Force	Employment	Unemployment	Rate
Central Naugatuck, CT	58,562	55,675	2,888	4.9%
Danbury, CT	85,697	81,093	4,604	5.4%
Lower Naugatuck, CT	37,308	35,029	2,279	6.1%
Norwalk, CT	85,398	31,949	3,449	4.0%
Torrington, CT	44,378	41,395	2,983	6.7%
West Haven, CT	77,829	73,927	3,902	5.0%
Berkshire County, MA (Only communities in study area)	52,283	49,245	3,038	5.8%

Communities involved in the Berkshire County statistics are Alford, Dalton, Egremont, Gt. Barrington, Hinsdale, Lanesborough, Lee, Lenox, Monterey, New Marlborough, Pittsfield, Richmond, Sheffield, Stockbridge, Tyringham, Washington, West Stockbridge, Windsor, Mt. Washington.

Source: (MA data) - Massachusetts/Cities and Towns Vol. 4 No. 10 October 1980.
(CT Data) - Annual Planning Information, Fiscal Year 81, Connecticut Balance of State

Population Characteristics

The 19 communities in the Massachusetts portion of the basin experienced a 6 percent increase in population between 1960 and 1970 even though Pittsfield and New Marlborough decreased in population. In the 10 year period between 1970 and 1980 the overall population decreased by 3.5 percent, with the communities of Dalton, Great Barrington, Lee, Pittsfield and West Stockbridge losing people. Pittsfield lost less than 1000 people from 1960-1970 and almost 6000 from 1970-1980.

The 44 communities in the Connecticut portion of the Housatonic Basin experienced an increase in population for both periods 1960-1970 and 1970-1980. The major difference is the percent increase was almost 3 times higher for the 1960-1970 period. Table A-9 shows the 1960, 1970 and 1980 populations and the percentage increases from 1960-1970 and 1970-1980. In the Connecticut portion of the basin only 4 towns showed a population decrease from 1970-1980, Ansonia, Derby, Torrington and Waterbury. The town experiencing the largest percentage increase was Southbury at 80.3 percent.

Danbury experienced an increase of almost 8500 people while Waterbury's population decreased by 5000 in the 1970-1980 period.

There are 14 communities in the southwestern portion of Connecticut which have been added to the water supply portion of the study area. This area has experienced a 3.0 percent decrease in population in the past 10 years similar to Massachusetts. As shown on Plate 3 in the Main Report, half of the 14 communities, those along the coast, have had population decreases. For the 1960-1970 period this entire area, except Bridgeport, experienced substantial population increases.

Throughout the entire area there are 3 communities with over 100,000 people; Bridgeport, Stamford and Waterbury. And there are 7 between 50,000 and 100,000; Pittsfield in Massachusetts and Danbury, Milford, Stratford, Fairfield, Greenwich and Norwalk, Connecticut.

The average density of population in 1980 for the entire study area was 642 people per square mile, 790 people per square mile in Connecticut and 187 in Massachusetts. Sixteen of the study area's communities have population densities over 1000 people per square mile. These communities are generally concentrated along the southern portion of the study area. With the exception of Pittsfield in Massachusetts. Overall, densities ranged from as low as 4 persons per square mile in Mt. Washington, Massachusetts to a high of 8848 persons in Bridgeport, Connecticut. The following Table A-10 lists the communities and their densities.

TABLE A-9

POPULATION OF MUNICIPALITIES
WITHIN THE STUDY AREA

MASSACHUSETTS

COMMUNITY	POPULATION 1960	POPULATION 1970	POPULATION 1980	PERCENT CHANGE 1960-1970	1970-1980
Alford	256	302	394	18.0	30.5
Dalton	6,436	7,505	6,797	16.6	-9.4
Egremont	895	1,138	1,311	27.2	15.2
Great Barrington	6,624	7,537	7,405	13.8	-1.8
Hinsdale	1,414	1,588	1,707	12.3	7.5
Lanesborough	2,933	2,972	3,131	1.3	5.3
Lee	5,271	6,426	6,247	21.9	-2.7
Lenox	4,253	5,804	6,523	36.5	12.4
Monterey	480	600	818	25.0	36.3
New Marlborough	1,083	1,031	1,160	-4.8	12.5
Pittsfield	57,879	57,020	51,974	-1.5	-8.8
Richmond	890	1,461	1,659	64.2	13.6
Sheffield	2,138	2,374	2,743	11.0	15.5
Stockbridge	2,161	2,312	2,328	7.0	0.7
Tyringham	197	234	344	18.8	47.0
Washington	290	406	587	40.0	44.6
West Stockbridge	1,244	1,354	1,280	8.8	-5.5
Windsor	384	468	598	21.9	27.8
Mt. Washington	--	52	93	--	78.8
Totals	94,828	100,584	97,099	+6.1	-3.5

CONNECTICUT

COMMUNITY	POPULATION 1960	POPULATION 1970	POPULATION 1980	PERCENT CHANGE 1960-1970	1970-1980
Ansonia	19,819	21,160	19,039	6.8	-10.0
Beacon Falls	2,886	3,546	3,995	22.9	12.7
Bethany	2,384	3,857	4,330	61.8	12.3
Bethel	8,200	10,945	16,004	33.5	46.2
Bethlehem	1,486	1,923	2,573	29.4	33.8
Bridgewater	898	1,277	1,563	42.2	22.4
Brookfield	3,405	9,688	12,872	184.5	32.9
Canaan	1,146	931	1,002	-5.5	7.6
Cornwall	1,051	1,177	1,288	12.0	9.4
Danbury	39,832	50,871	60,470	27.7	19.3
Derby	12,132	12,599	12,346	3.9	-2.0
Goshen	1,288	1,351	1,706	4.9	26.3
Harwinton	3,344	4,318	4,889	29.1	13.2
Kent	1,686	1,990	2,505	18.0	25.9
Litchfield	6,264	7,399	7,605	18.1	2.8
Middlebury	4,785	5,542	5,995	15.8	8.2

TABLE A-9 (Cont.)

COMMUNITY	POPULATION 1960	POPULATION 1970	POPULATION 1980	PERCENT CHANGE 1960-1970	PERCENT CHANGE 1970-1980
Milford	41,662	50,858	50,898	22.1	0.1
Monroe	6,402	12,047	14,010	90.5	16.3
Naugatuck	19,511	23,034	26,456	17.7	14.9
Morris	1,190	1,609	1,899	35.2	18.0
New Fairfield	3,355	6,991	11,260	108.4	61.1
New Milford	8,318	14,601	19,420	75.5	33.0
Newtown	11,373	16,942	19,107	49.0	12.8
Norfolk	1,827	2,073	2,156	13.5	4.0
North Canaan	2,836	3,045	3,185	7.4	4.6
Oxford	3,292	4,480	6,643	36.1	48.1
Plymouth	8,981	10,321	10,732	14.9	4.0
Prospect	4,367	6,596	6,807	51.0	4.0
Roxbury	912	1,238	1,468	5.8	18.6
Salisbury	3,309	3,573	3,896	8.0	9.0
Seymour	10,100	12,776	13,434	26.5	5.2
Sharon	2,141	2,491	2,623	16.4	5.3
Shelton	18,190	27,165	31,314	49.3	15.3
Sherman	825	1,459	2,281	76.9	56.2
Southbury	5,186	7,852	14,156	51.4	80.3
Stratford	45,012	49,775	50,541	10.6	1.5
Thomaston	5,850	6,233	6,276	6.6	0.7
Torrington	30,045	31,952	30,987	6.4	-3.0
Warren	600	827	1,027	37.8	24.2
Washington	2,603	3,121	3,657	19.9	17.2
Waterbury	107,130	108,033	103,266	0.8	-4.4
Watertown	14,980	18,610	19,489	24.2	4.7
Wolcott	8,889	12,495	13,088	40.6	4.1
Woodbury	3,910	5,869	6,942	50.1	18.3
Totals	483,259	554,587	635,200	21.1	14.5
Additional Communities					
Bridgeport	156,700	156,542	142,546	-0.1	-9.0
Darien	18,400	20,336	18,892	10.5	-7.1
Easton	3,400	4,885	5,962	43.7	22.0
Fairfield	46,200	56,487	54,849	22.2	-2.9
Greenwich	53,800	59,755	59,578	11.1	-0.3
New Canaan	13,500	17,451	17,931	29.2	2.6
Norwalk	67,800	79,288	77,767	16.9	-1.9
Redding	3,359	5,590	7,272	66.4	30.1
Ridgefield	8,165	18,188	20,120	122.8	10.6
Stamford	92,700	108,798	102,453	17.4	-5.8
Trumbull	20,400	31,394	32,989	53.9	5.2
Weston	4,000	7,417	8,284	85.4	11.7
Westport	21,000	27,318	25,290	30.1	-7.4
Wilton	8,000	13,572	15,351	69.7	13.1
Totals	517,424	607,021	589,284	+17.3	-2.9
Grand Total	1,095,511	1,262,479	1,321,583	15.2	4.4

TABLE A-10

CONNECTICUT

COMMUNITY	SQ. MI. LAND AREA	1980 DENSITY/SQ.MI	COMMUNITY	SQ. MI. LAND AREA	1980 DENSITY/SQ.MI
Ansonia	6.2	303	Torrington	39.6	782
Beacon Falls	9.8	408	Warren	27.4	37
Bethany	20.7	207	Washington	38.1	95
Bethel	16.9	931	Waterbury	27.6	3742
Bethlehem	19.7	131	Watertown	29.5	661
Bridgewater	16.3	95	Wolcott	20.0	648
Brookfield	19.9	636	Woodbury	36.7	189
Canaan	33.1	30	Bridgeport	16.1	8848
Cornwall	46.4	28	Darien	12.9	1464
Danbury	43.9	1351	Easton	27.5	216
Derby	5.2	2343	Fairfield	29.8	1836
Goshen	44.7	38	Greenwich	47.3	1260
Harwinton	31.3	157	New Canaan	23.0	780
Kent	49.0	51	Norwalk	22.0	3535
Litchfield	56.7	134	Redding	31.8	2689
Middlebury	17.5	343	Ridgefield	34.7	577
Milford	22.3	2282	Stamford	38.1	2689
Monroe	26.2	533	Trumbull	23.3	1417
Morris	17.2	111	Weston	19.9	416
Naugatuck	15.9	1664	Westport	19.9	1271
New Fairfield	20.7	533	Wilton	26.4	581
New Milford	62.8	308			
Newtown	58.5	321			
Norfolk	45.6	47			
North Canaan	19.6	162			
Oxford	32.6	199			
Plymouth	22.2	484			
Prospect	14.2	479			
Roxbury	26.4	55			
Salisbury	57.6	68			
Seymour	14.4	927			
Sharon	59.8	44			
Shelton	30.5	1030			
Sherman	22.0	104			
Southbury	40.7	348			
Stratford	17.3	2921			
Thomaston	12.0	523			

TABLE A-11 (Cont.)

MASSACHUSETTS

COMMUNITY	SQ. MI. LAND AREA	1980 DENSITY/SQ.MI
Alford	11.6	34
Dalton	22.1	308
Egremont	18.9	69
Great Barrington	45.7	162
Hinsdale	21.7	79
Lanesborough	29.2	107
Lee	26.5	235
Lenox	21.7	301
Monterey	27.2	30
New Marlborough	48.0	24
Pittsfield	40.4	1286
Richmond	19.1	87
Sheffield	48.7	56
Stockbridge	23.7	98
Tyringham	19.0	18
Washington	38.8	15
West Stockbridge	18.6	69
Windsor	35.3	17
Mt. Washington	22.3	4

Recreation. Recreational activities represent a major demand on the water resources of the basin, particularly in the main stem Housatonic and Shepaug subbasins. The basin's recreational resources support diverse land and waterbased activities, and attract many users from out of the basin. Major recreational water bodies include large artificial impoundments such as Lakes Candlewood, Lillinonah, and Zoar; the Shepaug River and the upper Housatonic in Connecticut; Stockbridge Bowl, Onata Lake, and several other recreational lakes in Massachusetts; and Long Island Sound and the Housatonic estuary.

Public recreational lands amount to over 100,000 acres in the basin, or about 10 percent of the basin's area. This includes nearly 70,000 acres of state forests, 7,000 acres of state parks, 12,000 acres of other state owned lands, and 16,000 acres leased by Connecticut for hunting. In addition, 15,000 acres are held for conservation by land trusts, and 13,000 acres are privately owned recreation lands. Most of the large holdings are in the Massachusetts and upper Connecticut main stem subbasins, while the more urbanized lower basin has the fewest public recreational opportunities.

The waters of the basin provide excellent opportunities for boating, fishing, white water canoeing, and swimming. Fifty-two or 13 percent of the basin's 405 lakes, ponds, and reservoirs have public access for recreation. However, a larger proportion of the basin's total water area is available for recreation because it is at the larger lakes that access has been provided.

Fishing is the major activity on the basin's rivers, streams, and ponds, and all three basin states stock recreational waters. Connecticut stocks 54 stream segments and 11 ponds, Massachusetts stocks 32 stream segments and numerous ponds, and New York stocks 11 stream segments and one pond in the basin. Most ponds and streams also have naturally occurring fish species such as chain pickerel, large mouth bass, and yellow perch.

The Connecticut DEP has a program for leasing and acquisition of stream banks to provide public access for fishing. No such program exists in Massachusetts, where access is more limited.

The type and amount of recreational opportunities available varies by subbasin. In the upper Massachusetts main stem subbasin, a number of recreational lakes, many of which are privately owned, attract users from outside the basin, increasing the summer populations of several towns.

In the upper Connecticut mainstem and Shepaug subbasins, white water canoeing, kayaking, and fly fishing are important activities, also attracting many users from out of the basin. Some potential for conflicts between fishing and canoeing exists, but this is minimized by the short period of overlap -- in late spring -- in the peak season of these two activities. Flow levels controlled by several hydropower dams also affect canoeing, but adequate flows are generally maintained during mid-day hours. Segments of both the Shepaug and the upper Housatonic in Connecticut have been nominated for inclusion in the National Wild and Scenic Rivers System.

In the middle and lower Connecticut mainstem subbasins, large artificial impoundments provide the major water based recreation opportunities. Candlewood Lake, a pumped storage reservoir, and Lakes Zoar and Lillinonah, run-of-the-river reservoirs, provide opportunities for motor boating, fishing, and swimming.

In the lower Connecticut mainstem subbasin, the tidal Housatonic estuary and Long Island Sound shore support coastal recreational activities. The only State-owned portion of the shore is Silver Sands State Park, but this 293 acre park with 3100 feet of shoreline is undeveloped due to water quality and ownership problems. The State also owns Wheeler Wildlife area, an 812 acre tract of estuarine wetlands at the mouth of the Housatonic in Milford, which is open for hunting. Public access to the lower Housatonic near its mouth is limited by urban and industrial development and a railroad on the eastern shore. The river is tidal for 12.2 miles upstream from its mouth, and the Corps of Engineers maintains a navigable channel in this segment. There is one marina and one boat club on the river. The Long Island Sound Study concluded that the tidal portion of the river could support increased recreational boating and marina facilities, with an additional capacity of 1100 boat slips.

Transportation

In the Massachusetts portion of the Housatonic the major roadway is the Massachusetts Turnpike which runs east to west across the State. Route 7 is the major north to south highway.

In Connecticut the major highways running north to south are Rt. 7, Rt. 15, Rt. 202 and Rt. 63. Running east to west are Rt. 44, Rt. 84, and Rt. 95 which follows the coast into New York City.

Summary

The communities of the Housatonic River Basin seem to be following a predictable growth pattern. The population statistics and projections, as stated earlier, indicate that people are moving out of the central cities into the suburbs and more rural areas. This trend accounts for the growth patterns in all the areas of development.

In the area of land use, the undeveloped open areas and woodlands are expected to be used mainly for residential purposes. Along with the growth of the suburbs will be the growth in the services industry which will be necessary in order to "service" the growing communities. Areas such as the southwestern portion of Connecticut will continue rapid growth as a " bedroom community" of New York City. Much of the residential land use in the Massachusetts portion of the basin is for vacation and second homes because of the vast outdoor recreational resources available. This trend will be a major factor in the development of open land for residential purposes and the resistance to major industrial development in that area.

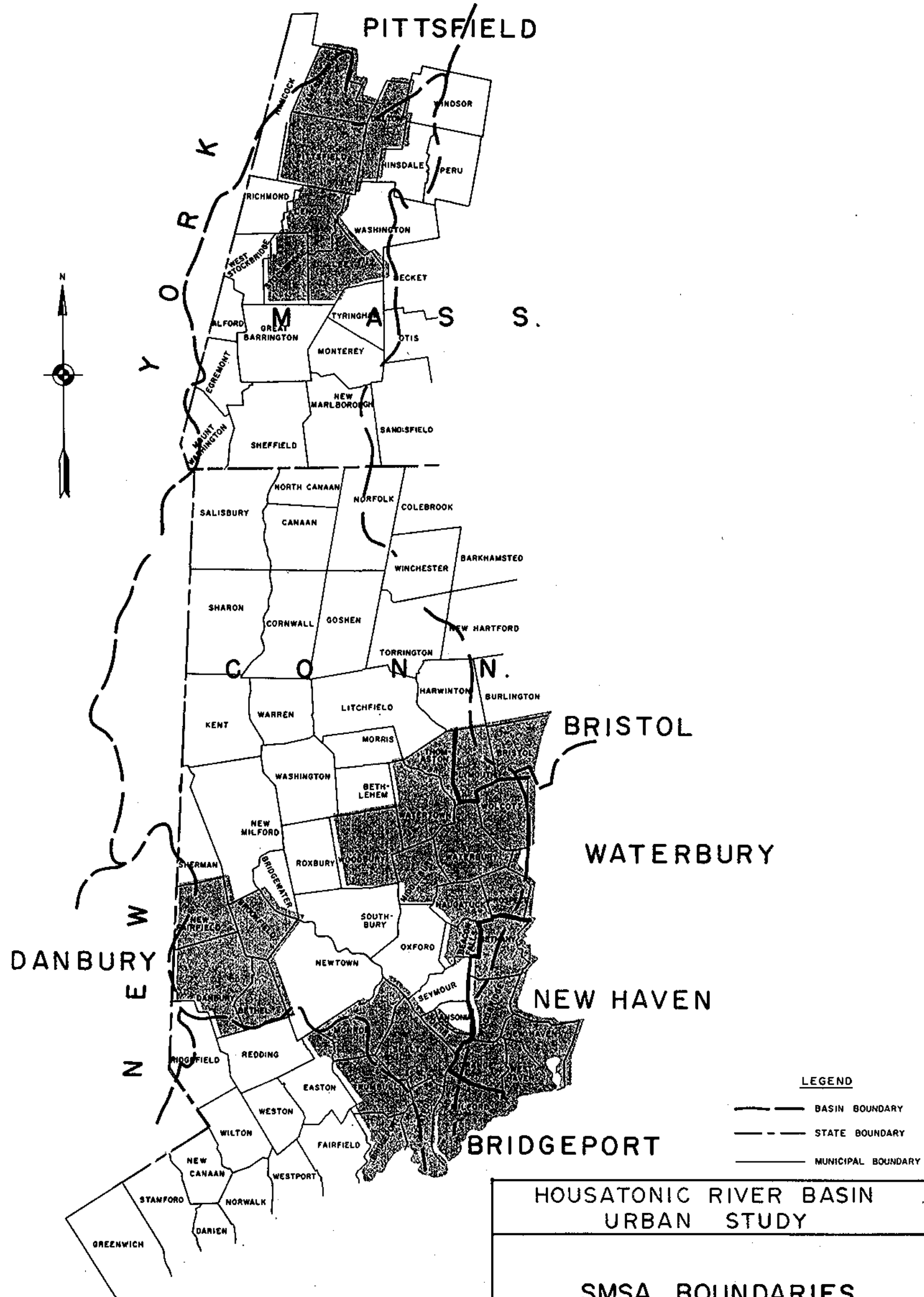
Growth in the commercial and industrial areas should even-off in the next few decades. The availability of key resources will be a major determinant in the development of manufacturing in the basin, with commercial growth occurring mainly in the suburban areas.

Six Standard Metropolitan Statistical Areas (SMSA) are located either wholly or partially within the study area. These SMSA's are Danbury, Bristol, Bridgeport, New Haven, Waterbury, and Pittsfield in Massachusetts. The data is given in Table A-11 and their location is shown graphically on Plate A-3. As shown on Table A-11, about 30 percent of the region's total land area and over 73 percent of its 1980 population are included in these six SMSA's.

TABLE A-11
PERTINENT DATA

Standard Metropolitan Statistical Areas (SMSA)
within Housatonic River Basin Study Area Boundaries

SMSA	Area Sq. Mile	1980 Population	1980 Density Population/Sq. Mile
Danbury	101.4	98,721	974
Bridgeport	119.6	192,129	1,606
Waterbury	183.2	192,174	1,049
New Haven	20.7	4,293	208
Bristol	22.2	10,745	484
Pittsfield	163.6	77,000	471
TOTALS	610.7	575,062	921



HOUSATONIC RIVER BASIN
URBAN STUDY

SMSA BOUNDARIES

NOT TO SCALE

WITHOUT PROJECT CONDITIONS

This section describes the most probable future expected for the study area under the assumption that no new water resources projects will be developed in the Housatonic River Basin. Alternative futures presented in this report are assessed and evaluated by comparison to the "without project" condition.

Water Supply.

Introduction. The following sections present the water supply needs investigated in this study and utilized in the specifications of planning objectives. The methodology used in estimating future water demands is also presented to provide the basis of projections.

Other water and related land resources needs within the study area are described in subsequent sections of the report.

Existing Conditions Summary. Data on existing water supply and demand within the study area were presented in the "Existing Conditions" section earlier in this report. The data shows that in 1978 public systems serving the study area supplied water to more than 975,000 people. Over 150 million gallons is supplied daily by the 131 water systems in Connecticut and almost 18 million gallons per day by the 15 water utilities in Massachusetts.

The existing public water demand consists of residential, commercial and industrial usage and also includes "unaccounted for" water associated with leakage and various municipal services such as fire-protection needs.

Projection Methodology. To estimate future water supply requirements for the study area, it was necessary to base projections of future usage on existing data and past trends of water consumption in the region.

Water requirements were estimated for the years 1980, 2000 and 2030. The year 1980 was taken as the base year while 2000 and 2030 were chosen as the time frames for short-term and long-term needs, respectively.

Future public water demands for each time frame were based on estimates and projections of the following:

- Population of the service area
- Percentage of the population served
- Per capita consumption (residential and commercial)
- Industrial water use

Data on the above were gathered to determine water supply usage in 1980, which then formed the basis for projections to 2000 and 2030. The accuracy of estimates of future water use is dependent on the accuracy of the projections and estimates made for the component parameters. In making estimates of future water use no direct allowance was made for the impact of changed policies on water consumptions nor was any allowance made for the possibility that water shortages could restrict population growth.

Population. The population projections, for Connecticut, were made by the Office of Policy and Management. The 2030 projections were completed in November 1979 and were adjusted upon receipt of the 1980 census figures. The adjusted projections are shown on Table A-12.

The Massachusetts population projections to the year 2000 were estimated by the State for use by the Section 208 studies. These figures were then adjusted using the 1980 census data. The projected estimates for 1975, 1980, 1985, 1990, 1995 and 2000 were plotted graphically for each community. The curves were then extrapolated to the year 2030. The resulting population projections are shown on Table A-13.

Population Served. Projected population served within the study area was based upon estimates of population served by existing water supply systems. It has been assumed that the population served to total population ratio will remain constant throughout the study period for each community. This assumption is based on a careful examination of the 1970 and existing population served to total population ratio of 27 water systems, coupled with a knowledge of the water systems and communities in the study area. Of the 27 that were investigated, 9 showed no change in ratio even though the population increased. Ten of the systems actually decreased due to the population increasing at a faster rate than the population served. The remaining 8 water systems showed an increase in the population - population served ratio.

Four of the eight systems are in towns that have 100 percent of their population served. The Heritage Village Water Company was assumed to increase from serving 35 percent of Southbury to 50 percent. The Ridgefield and Torrington Water Companies were assumed to continue the same population-to-population served ratio as a result of the topography and the rural nature of these communities. Estimates of population served for 2000 and 2030 are shown on Table A-14 for Connecticut and Table A-15 for Massachusetts.

Per Capita Consumption. The existing (1980) per capita consumption figures were obtained by dividing the combined residential and commercial average daily demand by the population served. Future values of per capita consumption were largely based on projected increases of 0.5 gpcd (gallons per capita per day) per year. Therefore, per capita increases of 10 gpcd between 1980 and 2000 and 15 gpcd between 2000 and 2030 were added to all existing residential water consumption values.

TABLE A-12
CONNECTICUT - POPULATION PROJECTIONS

Community	1990	2000	2030
Ansonia	19,060	19,020	18,600
Beacon Falls	4,250	4,400	6,100
Bethany	4,600	4,870	5,400
Bethel	17,800	19,750	23,800
Bethlehem	2,860	3,130	3,500
Bridgeport	142,800	143,680	149,000
Bridgewater	1,680	1,800	2,300
Brookfield	14,650	16,750	20,150
Canaan	1,130	1,150	1,300
Cornwall	1,330	1,350	1,450
Danbury	63,300	66,400	70,300
Darien	19,600	19,800	21,600
Derby	12,650	12,950	13,950
Easton	6,600	7,360	8,200
Fairfield	55,220	51,660	46,400
Goshen	1,950	2,200	2,450
Greenwich	61,000	61,900	66,400
Harwinton	5,490	5,940	6,550
Kent	2,750	2,950	3,600
Litchfield	8,020	8,050	8,400
Middlebury	6,130	6,130	7,300
Milford	51,750	52,650	55,150
Monroe	15,940	17,570	20,000
Morris	1,940	1,980	2,050
Naugatuck	27,700	29,300	30,500
New Canaan	19,390	20,410	21,600
New Fairfield	12,400	13,770	16,000
New Milford	21,000	23,000	25,900
Newtown	21,000	23,800	26,800
Norfolk	2,140	2,200	2,300
North Canaan	3,130	3,150	3,400
Norwalk	79,000	79,240	79,000
Oxford	7,580	8,440	9,400
Plymouth	11,420	11,790	12,500
Prospect	6,860	6,680	7,500
Redding	8,360	9,640	12,000
Ridgefield	21,700	23,000	25,000
Roxbury	1,750	2,000	2,250
Salisbury	3,880	3,940	4,250
Seymour	15,300	17,600	19,700
Sharon	2,750	2,800	3,000
Shelton	34,320	36,300	40,000
Sherman	2,700	3,100	3,600
Southbury	15,100	16,600	19,000
Stamford	103,500	104,500	107,500

TABLE 12 (Cont.)

Community	1990	2000	2030
Stratford	52,280	52,370	55,000
Thomaston	6,590	6,800	7,000
Torrington	31,500	32,000	33,000
Trumbull	35,310	34,540	32,400
Warren	1,060	1,090	1,200
Washington	3,700	3,800	4,200
Waterbury	103,700	105,500	107,800
Watertown	20,400	21,000	24,000
Weston	9,400	9,770	11,000
Westport	25,400	24,570	30,200
Wilton	17,350	18,850	23,600
Wolcott	13,630	13,970	15,800
Woodbury	7,280	7,320	7,800
Total	1,271,350	1,360,460	1,388,150

TABLE A-13

Population Projections - Massachusetts

Community	1990	2000	2015	2030
Alford	520	550	650	750
Dalton	6,840	7,100	7,550	8,000
Egremont	1,4990	1,725	2,100	2,500
Gt. Barrington	7,500	8,100	9,000	9,800
Hinsdale	1,870	2,300	2,900	3,700
Lanesborough	3,400	3,800	4,300	4,800
Lee	6,460	6,800	7,400	7,800
Lenox	7,300	8,100	9,300	10,300
Monterey	1,000	1,150	1,350	1,600
Mt. Washington	150	175	225	275
New Marlborough	1,280	1,450	1,650	1,900
Pittsfield	50,550	52,000	52,000	52,000
Richmond	1,900	2,150	2,500	2,850
Stockbridge	2,500	2,700	3,100	3,500
Sheffield	3,020	3,400	3,900	4,400
Tyringham	400	450	525	625
Washington	750	750	875	1,000
W. Stockbridge	1,450	1,490	1,600	1,750
Windsor	780	800	875	950
Total	99,160	104,990	111,800	118,500

Historically the rate of gallon per capita per day increase on a yearly basis for 1950-1965 was 1.3 gpcd. It dropped to about 1 gpcd betwen 1965-1975. It is felt by many that the rate will be 0.5 gpcd for the period from 1980-2030. It is believed due to the ever increasing use of low water consumption appliances such as dishwasters and washing machines. There is also much more voluntary and mandatory use of water saving devices such as low flow shower heads and toilets. There has been an increase of multi-unit housing in the form of apartment complexes, duplexes and condominiums. This trend is expected to continue into the foreseeable future. There is a much keener awareness of the environment and the fact that water is a limited resource.

Bridgeport Hydraulic is the largest water company in the basin serving over 360,000 people in 13 communities. I quote from recent projections they made: "It is expected that the rate of future increases in company-wide, per capita consumption will decrease markedly from the record of the past 20 years." The reasons given for the decreases are:

1. An expected substantial decline in the ratio of single houses built versus multiple dwellings or town houses because of the costs of construction maintenance, ad valorem taxes, interest, utilities and fuel for heating and cooling.

2. With the conservation movement and projected increases in water rates (due to expected inflation) there will be a greater consciousness of the cost and value of water and the public will be more careful in its water use. Accordingly, the per capita forecasts predict that:

a. Per capita use (other than industrial) will increase in the future at an average rate of 0.5 gallons per year.

b. Per capita use (other than industrial) in any zone, will taper off at 140 gcd which is the figure that the report adopts as the "ceiling" in large-lot suburban areas.

Average Day Residential and Commercial Demand. Values of the existing average day residential and commercial water demands were obtained by deducting from total demand the industrial water usage for each water supply agency. Industrial demands for existing systems were obtained by the total metered water use of major industries within the study area. Average day residential and commercial demands for the years 2000 and 2030 were obtained by multiplying the population served by the per capita water consumption for each water supply agency.

Average Day Industrial Demand. Existing industrial water usage within the study area was obtained from the water utilities, the State and studies done for Section 208. Industrial demands were aggregated by community according to a two digit Standard Industrial Classification (SIC) Code. The SIC Codes were established by the Federal Government to permit categorization and identification of industry. The codes are set up on a

TABLE A-14
POPULATION SERVED - CONNECTICUT

	1980 Pop. Served	2000 Pop. Served	2030 Pop. Served
VALLEY			
Ansoia	18841	19,020	18,600
Derby	12184	12,950	13,950
Seymour	89602	11,818	13,200
Shelton	20100	29,520	32,000
CENTRAL NAUGATUCK			
Beacon Falls	1758	2390	4420
Bethlehem	0	0	0
Middlebury	576	610	700
Naugatuck	21960	24050	25320
Oxford	163	860	1850
Prospect	480	470	530
Southbury	4530	8300	9500
Thomaston	3326	3600	3710
Waterbury	103266	104430	107800
Watertown	19489	21000	24000
Wolcott	100	200	160
Woodbury	3100	3290	3510
LITCHFIELD HILLS			
Goshen	260	330	370
Harwinton	0	0	0
Litchfield	2510	2660	2770
Morris	0	0	0
Norfolk	1530	1540	1610
Torrington	20760	21440	22110
HOUSATONIC VALLEY			
Bethel	12000	15210	18330
Bridgewater	0	0	0
Brookfield	3540	4690	5640
Danbury	42700	47810	50620
New Fairfield	2246	27810	50620
New Milford	10594	12650	14245
Newtown	6020	7850	8840
Redding	430	580	720
Ridgefield	15230	17480	19000
Sherman	660	899	1044

TABLE A-14 (cont'd)

	1980 Pop. Served	2000 Pop. Served	2030 Pop. Served
NORTHWESTERN			
Canaan	250	290	330
Cornwall	220	230	250
Kent	1750	2010	2380
North Canaan	1930	1920	2070
Roxbury	0	0	0
Salisbury	3070	3110	3360
Sharon	700	760	810
Warren	236	250	276
Washington	1048	1102	1218
SOUTHWESTERN			
Darien	16059	16830	18360
Greenwich	41695	42700	46480
New Canaan	9860	15300	21600
Norwalk	77767	79240	79000
Stamford	84525	85400	88700
Weston	250	1110	2750
Westport	24300	26020	35000
Wilton	770	1960	4550
GREATER BRIDGEPORT			
Bridgeport	142459	147460	155000
Easton	2130	4460	8100
Fairfield	54699	55400	52500
Monroe	5300	13540	20000
Stratford	50530	54730	55000
Trumbull	33011	35400	35000
OTHERS			
Bethany	20	240	270
Milford	48950	50540	52940
Pymouth	5050	5530	5880

TABLE A-15
POPULATION SERVED - MASSACHUSETTS

	1980 Pop. Served	2000 Pop. Served	2030 Pop. Served
Lee	6,500	6,800	7,800
Dalton	6,392	6,675	7,525
Egremont	833	1,100	1,600
Hinsdale	840	916	1,960
Lanesborough	2,400	2,900	3,700
Lenox	6,000	7,450	9,500
Monterey	200	290	400
Pittsfield	51,974	52,000	52,000
Richmond	40	55	70
Sheffield	1,242	1,540	2,000
W. Stockbridge	1,000	1,100	1,400
Stockbridge	2,255	2,600	3,400
Gt. Barrington	6,200	6,900	8,220
New Marlborough	220	290	380

2, 3 and 4 digit flexible system, with identification becoming more specific as the number of digits increase. For example, an industry with the Code 2822 would be identified in the following manner. The major industrial code -28- indicates chemicals and allied products; the industry group -282- further refines it as a manufacturer of either fibers, plastics, or rubber; the specific code -2822- identifies the plant as a manufacturer of Synthetic Rubber.

Future projections of publicly supplied industrial water demands were based on a theoretical model described by R. H. Stewart and I. Metzger in their article, "Industrial Water Forecasts," Journal American Water Works Association, March 1971.

Nine two digit SIC Code industries have been identified as major water users within the study area. These are listed below:

SIC Code	Definition
20	Food and Kindred Products
22	Textile Mill Products
26	Paper and Allied Products
28	Chemical and Allied Products
33	Primary Metal Industries
34	Fabricated Metal Products
35	Machinery (Except Electrical)
36	Electrical Machinery
39	Miscellaneous Manufacturing Industries

The methodology used to estimated the region's future industrial water demand is as follows:

1. Determine, and aggregate by SIC Code, the major water using industries by community, and their water demand for a base year (1980).

2. Determine, for each of the 9 identified water using industries, the ratio of future demand to the base year. This is accomplished by the formula: F = (EXO)/(RXT), where: F = ratio of water usage, per SIC Code, between the projected year and the base year

EXO = Employee Output factors, derived from the OBERS Series E Projections per SIC Code per future year

RXT = Recirculation and Technology factors, derived from the "Census of Manufacturing".

Table A-16 lists the F, EXO, and RXT factors per SCI Code per future target year which were used in estimating future industrial water demands.

TABLE A-16

"F" Factor Determination by SIC Code, by year
$F = (EXO)/(RXT)$

CONNECTICUT

SCI Code	2000 EXO	2000 RXT	2000 F	2030 EXO	2030 RXT	2030 F
20	1.3	2.35	.55	2.3	2.9	.8
22	.95	1.9	.5	1.25	2.25	.55
26	1.25	1.45	.85	2.7	2.05	1.3
28	1.4	.45	3.0	3.6	1.05	3.45
33	1.05	1.15	.9	1.5	1.35	1.1
34	1.3	.9	1.45	2.75	1.05	2.6
35	1.15	.85	1.35	2.2	.85	2.54
36	1.4	.8	1.7	3.8	1.0	3.8
39	1.25	1.45	.85	2.6	2.15	1.2
Others			1.0			1.5

MASSACHUSETTS

SCI Code	2000 EXO	2000 RXT	2000 F	2030 EXO	2030 RXT	2030 F
20	1.40	.95	1.45	2.35	1.04	2.25
22	.9	1.6	.55	1.05	2.0	.53
26	1.55	1.25	1.25	2.95	1.55	1.9
28	2.1	1.85	1.15	5.15	2.25	2.29
33	1.00	1.30	.77	1.4	1.35	1.04
35	1.50	.75	2.0	2.75	.90	3.06
36	1.65	1.70	.97	3.40	1.80	1.88
39	1.7	1.1	1.54	3.5	1.25	2.8
Others			1.0			1.5

Total Average Day Demand. Values for the total daily average demand include total municipally supplied residential and commercial, industrial and unaccounted for water. Data on existing water supply companies in the study area were obtained from unpublished records of the following:

- Department of Health Services
- Department of Environmental Protection
- Department of Public Utilities Control
- Regional Planning Agencies
- Water Utilities or Companies

Water Supply Needs

Municipal and industrial water supply needs were developed for the study area based upon the foregoing methodology and are shown in Table 2 of the Main Report for the "most probable future" condition. The small residential systems that serve under 100 customers in Connecticut were eliminated from study unless they happened to be the major system within the town. Most of the smaller systems eliminated are used only during the summer and there is very little information available on them.

Flood Problem Identification

Methodology

As a screening criteria, structures within the 100-year flood plain were identified for further investigation. Structures were determined to be within the 100-year flood plain by use of Flood Hazard Boundary maps or Flood Insurance Rate Maps and U.S.G.S. quadrangle maps (quadrangle maps were dated from 1969-1975, while flood maps were dated 1975-1981). With the exception of the mainstem Housatonic in Connecticut, existing aerial photography was not obtained.

Because quad sheeds (scale of 1:24,000) were used to identify structures, it was not possible to positively determine the structure's use. It was assumed that large buildings had either commercial or industrial uses and that all small buildings were residences.

A total of 3,785 structures 3,278 residential and 507 commercial or industrial were identified within the 100-year flood plain.(1) Table 3 in the Main Report presents the findings of the initial basin-wide identification of flood problems within each community.

Using the information in Table 3 as a guideline, a number of communities were selected for further investigation.

(1)Includes coastal areas of communities within basin.

A secondary screening process was then undertaken to direct study efforts to those structures which appeared to be suitable candidates for flood proofing. It was assumed that flood proofing of residences could only be economically justified for those structures within the 50-year flood plain. Therefore, only those residential areas with groups of at least 10 homes within the 50-year flood plain (based on best available mapping) were selected for further investigation. Flood proofing of commercial or industrial structures, however, may be economically justified for structures affected by the 100 to 500-year event (depending on type of construction and the value of damageable contents) and, therefore, a different screening criteria was applied for those areas with commercial or industrial structures. Communities with significant commercial-industrial development within the 100-year flood plain were selected for further study.

Based on the above criteria, the following 14 communities (listed in downstream order were selected for detailed investigations. These communities are also shown on Plate 15 in the Main Report.

Massachusetts:

Dalton
Pittsfield
Lee

Connecticut:

Kent	Oxford-Seymour
New Milford	Derby
Brookfield	Shelton
Danbury	Watertown
Newtown	Torrington

Information compiled for the detailed investigations of these communities included:

- Identification of specific structures through field checks.

- Structure attributes such as foundation type, construction material and condition for each structure.

- Ground flood elevations for each structure as determined by third order leveling.

- Flood elevations at ground level for each structure obtained from flood insurance profiles.

- Stage damage estimates for residences based on generalized relationships developed in other Corps studies.

- Stage damage estimates for selected commercial and industrial structures.

- Stage frequency curves for each river reach where expected annual damages were to be computed.

The above data were used as inputs for HEC's Interactive Nonstructural Analysis Package, February 1980. This program computes expected annual damages for base conditions and is also used to calculate residual expected annual damages for various flood proofing alternatives.

Description of Flood Problems

Detailed investigation of the 14 communities indicates that several communities have severe flood problems. Table A-17 presents the flood problem for each community by the number of structures (and their expected annual damages where available) that would be affected by 20-year, 50-year, 100-year and greater than 100-year events.

The following sections describe the unique flood problems identified for each of the 14 communities in downstream order.

Massachusetts

1. Dalton. The major source of flooding in the town of Dalton is the East Branch Housatonic River, with a drainage area of less than 57 square miles. Past notable floods occurred in March 1936, September 1938 and January 1949 floods. These floods all have estimated recurrence intervals of less than 50 years.

The primary damage sites are the Center Pond area and "Mill Reach". A 40 unit elderly housing complex and 8 other residences are subject to flooding in the Center Pond area. Expected annual damages are $30,250 and $3,713 for the elderly housing and residences respectively. In addition to the large economic losses expected from a large flood at the elderly housing complex, there exists a potential loss of life situation. The 100-year flood inundates large sections of the complex and a 500-year flood would result in flood depths of up to six feet above some first floors. Evacuation efforts would be hindered because the single access road to the complex would also be inundated.

Downstream from the Center Pond area, there are 5 large mills located on the banks of the East Branch within the 8,000 foot Mill Reach, two of which get flooded. Detailed damage estimates are not available for this area, however several of the mills appear to be major employers in the town, and a large flood could have a significant effect on the local economy.

TABLE A-17

STRUCTURES AFFECTED BY VARIOUS FLOOD EVENTS
AND THEIR EXPECTED ANNUAL DAMAGES

Community	20 - Year Flood		50 - Year Flood		100 - Year Flood		Greater than 100 - Year Flood		TOTAL	
	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)
Dalton										
Residential	0	0	4	3.20	0	0	4	.51	8	3.71
Commercial-(1),(2)	10	15.67	16	11.65	10	2.46	4	.47	40	30.25
Industrial	-	-		-	-	-	-	-	5	-
Pittsfield										
Residential	129	367.71	195	150.70	95	33.32	41	2.10	460	553.83
Commercial-(3)	7	71.25	18	87.83	23	189.17	24	22.85	72	371.10
Industrial	0	0	3	-	2	-	1	-	36	-
Lee										
Residential	13	20.48	15	10.43	5	1.41	4	.69	37	33.01
Commercial-	5	65.39	4	5.88	4	1.64	4	1.69	17	74.60
Industrial	4	-	1	-	0	0	0	0	5	-
Kent										
Residential	0	0	0	0	0	0	14	1.48	14	1.48
Commercial-Industrial	2	-	3	-	10	-	1	-	16	-
New Milford										
Residential	19	24.43	7	5.80	6	3.14	10	5.55	42	38.92
Commercial-	24	591.50	18	42.57	12	48.85	1	1.49	55	684.41
Industrial	0	0	1	-	2	-	9	-	12	-
Brookfield										
Residential(4)	-	-	-	-	-	-	-	-	-	-
Commercial-Industrial	0	0	0	0	4	0	9	-	13	-

TABLE A-17 (continued)

Community	20 - Year Flood Structures Affected	20 - Year Flood EAD (000's)	50 - Year Flood Structures Affected	50 - Year Flood EAD (000's)	100 - Year Flood Structures Affected	100 - Year Flood EAD (000's)	Greater than 100 - Year Flood Structures Affected	Greater than 100 - Year Flood EAD (000's)	TOTAL Structures Affected	TOTAL EAD (000's)
Danbury										
Residential(5)	-	-	-	-	-	-	-	-	-	-
Commercial-Industrial	4	-	18	-	24	-	32	-	78	-
Newtown										
Residential	0	0	3	2.32	10	3.92	29	4.96	42	11.20
Commercial-Industrial(6)	-	-	-	-	-	-	-	-	-	-
Oxford-Seymour										
Residential	32	143.09	42	48.18	43	24.59	2	.35	119	216.21
Commercial-Industrial	3	-	3	-	1	-	0	0	7	-
Derby										
Residential	19	44.32	0	0	0	0	0	0	19	44.32
Commercial-Industrial	0	0	2	-	3	-	3	-	8	-
Shelton										
Residential	69	122.35	41	14.10	7	.63	3	.40	120	137.48
Commercial-Industrial	4	-	6	-	3	-	9	-	22	-
Watertown										
Residential(7)	-	-	-	-	-	-	-	-	-	-
Commercial-Industrial	0	0	1	-	3	-	4	-	8	-

TABLE A-17 (continued)

Community	20 - Year Flood		50 - Year Flood		100 - Year Flood		Greater than 100 - Year Flood		TOTAL	
	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)	Structures Affected	EAD (000's)
Torrington										
Residential (8)	-	-	-	-	-	-	-	-	38	-
Commercial-Industrial	1	-	1	-	2	-	7	-	11	-
TOTAL										
Residential	281	722.38	307	234.73	166	67.01	107	16.04	899	1,040.16
Commercial-	46	743.81	56	147.93	49	242.12	33	26.50	184	1,160.36
Industrial	18	-	39	-	54	-	75	-	221	-
	345	1,466.19	402	382.66	269	309.13	215	43.60	1304	2,200.52

NOTE: Expected annual damages were obtained directly from computer print outs and are not intended to denote a degree of accuracy.

FOOTNOTES TO TABLE A-17:

(1) Each unit of the elderly housing complex was considered a separate structure.

(2) Damage estimates are required to determine the flood event that affects the 5 mill complexes in Dalton.

(3) Exact elevations were not obtained for 30 commercial-industrial structures near Silver Lake. It is estimated that most of these structures would be affected by less than a 100-year flood.

(4) Residential development in Brookfield was not investigated.

(5) Residential development in Danbury was not investigated.

(6) Commercial-industrial development in Newtown was not investigated.

(7) Residential development in Watertown was not investigated.

(8) Detailed hydraulic information was not available to determine the exact flood hazard for residences in Torrington.

2. Pittsfield. Major sources of flooding in the city of Pittsfield are the East, Southwest and West Branches of the Housatonic. Because both the Southwest and West Branches are currently being studied under a Corps of Engineers continuing authority (Section 205) this study investigated the East Branch only. Notable floods on the East Branch, with a drainage area of 70 square miles, have occurred in March 1936, September 1938 and January 1949. The September 1938 flood with an estimated recurrence interval of less than 50 years is the flood of record, but flood heights during the January 1949 exceed the September 1938 flood heights at some locations. This may have been the result of ice jams. The January 1949 flood was the most costly in terms of dollar damages and the Commonwealth of Massachusetts reportedly spent approximately $2,000,000 on a program to clean-up the stream channels in the flooded areas following this storm.

There are 460 residences and 108 commercial or industrial structures within the 100-year floodplain upstream of the Elm Street bridge. Total expected annual damages for structures within the 100-year flood plain are in excess of $800,000 with the majority of this damage in the Elm Street-Brattle Brook confluence reach. Upstream there is a significant amount of commercial development in the Coltsville area flood plain which is also affected, but flood depths at these structures do not exceed 2 feet for the 100-year event and 4 feet for the 500-year event.

In the principal damage area it appears that channel constrictions downstream of the Elm Street Bridge have a significant effect on the flood profiles. There are over 450 residences within this reach which would be affected by the 100-year event. Expected annual damages for these residences are about $550,000. There is also a substantial amount of commercial and industrial development within this reach. Approximately 30 commercial establishments and a portion of the large General Electric Plant were identified to be within the 50-year flood plain. Expected annual damages for the commercial structures is unavailable, however expected annual damages based on conservative preliminary damage estimates for the General Electric complex in the Silver Lake region are about $260,000. Because General Electric employs approximately 30 percent of the working population in Pittsfield, it is expected that a large flood could have a significant effect on the local economy.

Additionally, some of the work being undertaken by General Electric is related to national defense programs. A 50-year flood would negatively impact national defense objectives where tank components are reportedly manufactured. Similarly, a 50-year flood would affect the GE's Naval Sea Systems Command Building located in the Coltsville area.

3. Lee. The major source of flooding in the town of Lee is the Housatonic River which flows along side of the business district. Major floods on the Housatonic have occurred in March 1936, September 1938 and January 1949. These floods all have recurrence intervals of less than 100-years.

The majority of flood damage in Lee occurs in the 8,000 foot reach between the Massachusetts Route 102 and Main Street bridges. Expected annual damages for the 37 homes and 22 commercial-industrial structures within this reach exceed $105,000 (residential = $30,000 and commercial-industrial = $75,000).

Connecticut

4. Kent. The primary source of flooding in the town of Kent is the Housatonic River, with a drainage area of 782 square miles. Major flooding has occurred in March 1936, September 1938, January 1949, August 1955, October 1955 and March 1977. These floods are believed to have recurrence intervals of less than 100-years. Additionally, ice jams are reported to occur just upstream of Bulls Bridge Dam. These ice jams could increase (especially lower frequency events) computed water surface elevations which were calculated assuming free flow conditions.

There are three areas subject to flooding from the Housatonic. The first area, approximately 2 miles upstream of Bulls Bridge Dam, is comprised of 14 homes. Expected annual damage at this site is $1,500. The second site, approximately 3.0 miles upstream of Bulls Bridge Dam, is the town sewage treatment plant. Damage estimates are not available for this facility, but flood depths of approximately 5 and 10 feet can be expected from 100 and 500-year floods respectively. The third area, at the confluence of Macedonia Brook with the Housatonic, includes the Kent School (private boarding school) and Kent Center School (public). Detailed damage estimates are not available for this area. The Kent Center School is at an elevation equal to the 100-year flood with flood waters from a 500-year event estimated to be 5 feet deep. At the Kent School, 4 athletic facilities and the science center would be affected by a 50-year flood.

In addition to the economic considerations of flooding in Kent, there are potential environmental problems caused by flooding at the sewage treatment plant and safety problems at the Kent School. Should a 100-year event occur at the school, with an approximate enrollment of 360 boys, all access roads would be inundated, making evacuation difficult.

5. New Milford. The major source of flooding in New Milford is the Housatonic River. A small commercial area in the village of Northville is also subject to flooding from the East Aspetuck River. Notable floods on the Housatonic (drainage area of 1,198 square miles) occurred in September 1938, January 1949, August 1955 and October 1955. Additionally, ice jams have been known to occur at Lovers Leap Gorge. These ice jams could increase (especially lower frequency events) computed water surface elevations which were calculated assuming free flow conditions. The flood of record, August 1955, with an estimated return period of less than 100-years, caused $600,000 in municipal and residential damages (this figure excludes industrial and personal property losses).

The primary damage area on the Housatonic is the 4 mile reach extending from Lovers Leap Gorge to Boardman Bridge. The 2,000 foot long Lovers Leap Gorge acts as a hydraulic construction and has a major effect on the water surface profiles extending 4 miles upstream. For example, flood elevations for the 100-year and 500-year floods are 16 and 32 feet respectively above the 10-year flood.

There are 45 residences, 68 commercial-industrial structures and 2 waste treatment facilities within the 100-year flood plain. Expected annual damages to these structures exceeds $725,000. The New Milford Nonwoven Corporation (formerly J. P. Stevens), alone has expected annual damages of about $165,000 while the King's Shopping Plaza, has expected annual damages of about $325,000. Both locations have 30-foot depths calculated for the 500-year event.

In addition to the economic impacts of flooding in this reach there are: environmental concerns should the sewage treatment plants be inundated and the potential for loss of life because of the flood depths experienced from even relatively frequent events. In addition, during a 500-year flood, the roads and bridges accessing residential areas would be flooded by depths ranging from 10 to 30 feet. Evacuation of these residences would be extremely difficult.

Evacuation of 3 residences on islands in the Housatonic would be even more difficult. It should be noted that damages cited are believed to be conservative and could be significantly higher if:

1) the effects of ice jams were considered,
2) public losses were considered, and
3) structures in the 500-year flood plain were included.

6. Brookfield. The primary source of flooding in the town of Brookfield is the Still River. Notable floods occurred in March 1936, September 1938, August 1955 and October 1955. The record October 1955 flood has a recurrence interval of approximately 100-years.

There are two areas subject to flooding from the Still River. The first area is a commercial development located at the Danbury-Brookfield town line. There are 9 commercial structures, including a large shopping plaza affected by flooding. Although flood stages from a 100-year flood are not excessive, depths can reach 6 feet during a 500-year event. The second area subject to flooding is an industrial park, where approximately 4 structures would be affected by a 500-year flood.

7. Danbury. There are several sources of flooding within the city of Danbury. Six areas were identified as having flood problems. Flooding is caused by Limekiln Brook, Sympaug Brook, Padanaram Brook, Kohanza Brook, and the Still River. Notable floods on the Still River occurred in March 1936, September 1938, August 1955 and October 1955. The record flood of October 1955 has an estimated recurrence interval of 100-years. The first

area in Danbury, affected by flood flows from the Still River, is approximately 4 miles downstream of the Corps of Engineers local protection project in Danbury. There are five commercial establishments subject to flooding from a 100-year event and four of these structures were identified as being within the 50-year flood plain. Flood heights of 1 and 5 feet are expected from 100 and 500-year events respectively.

The second area in Danbury is on the Still River, upstream of the city of Danbury's Central Flood Urban Renewal Project and 1/2 mile upstream of the Corps' local protection project. There are 17 commercial-industrial structures and 6 residences subject to flooding. These include 4 large industrial establishments and 3 buildings of recent construction affected by the 500-year flood. Flood depths of approximately 2 and 5 feet are expected from 100 and 500-year events respectively.

The third area in Danbury is located along the Still River and Limekiln Brook. Flooding on Limekiln Brook is the result of backwater from the Still River. The area is approximately 2 miles downstream of the Corps' local protection project. Development in this area consists of shopping plazas and establishments engaged in light industry and research and development. Most of this development has occurred since 1963. There are 18 structures which would be damaged by a 100-year flood and 11 of these buildings are within the 50-year flood plain. Approximately 20 additional structures including a fire station would be affected by the flooding of roads accessing this area. Flood depths of up to 3 and 9 feet from the 100 and 500-year floods respectively, can be expected at those structures within the 50-year flood plain.

The fourth area in Danbury is located on Sympaug Brook. There are 8 commercial-industrial structures whose first floor elevations are approximately equal to the 100-year flood. Flood depths of 1 to 4 feet can be expected from a 500-year event.

The fifth area in Danbury is located on Padanaram and Kohanza Brooks. The confluence of Padanaram Brook with the Still River is approximately 500 feet upstream of the Corps' local protection project. Most of the 25 structures within the 100-year flood plain have first floors at or above the 100-year flood elevation. Flood depths during a 500-year storm are expected to be about 2 feet for most of these structures. The fire station and surrounding roadways however are subject to flooding from a 100-year event.

The sixth area in Danbury is on the Still River, approximately 3 miles upstream of the local protection project. Located within this area are the Municipal airport (where approximately 150 airplanes are tied down), the Danbury Fairgrounds (which reportedly may be developed into a major retail shopping center), establishments engaged in light manufacturing or research and development (constructed since 1963), a trailer park and several residences. Detailed hydraulic data has not been developed for this reach of the Still River. Based on flood elevations immediately downstream, a 100-year flood would result in flood depths of approximately 2.5 feet at the center of the airport runways.

8. Newtown. The principal source of flooding in Newtown is the Housatonic River. Notable floods occurred in March 1936, September 1938, January 1949, August 1955 and October 1955. The October 1955 has an estimated recurrence interval of 100-years.

The area investigated is a small residential development located one mile downstream of Shepaug Dam on the Housatonic River. Forty-two homes are affected by the 100-year flood. Total expected annual damages for these homes is about $11,000. Although flood depths and damages are not excessive, evacuation of this area during a large flood would be difficult. Access roads would be inundated by 2.5 and 7 feet of water during a 100 and 500-year storms respectively. A portion of the sewage disposal facility for Fairfield State Hospital is within the flood plain of Deep Brook.

9. Oxford-Seymour. The principal source of flooding in the towns of Seymour and Oxford is the Housatonic River. Notable floods have occurred in March 1936, September 1938, January 1949, August and October 1955. The October 1955 flood of record has a recurrence interval of approximately 120 years. The primary damage area is a one mile reach of the Housatonic River at the Seymour-Oxford town line. A second damage area is located 1.5 miles downstream of the Oxford-Seymour town line.

There are 6 commercial establishments and 70 residences within the 100-year flood plain at the first area. The majority of these structures are within the 50-year flood plain. Expected annual damages for the residences is about $160,000. In addition to the economic impacts of a flood in this area is the concern for safety. Flood depths of 6 and 12 feet (100 and 500-year floods) can be expected at many homes as well as State Highway 34, the only road accessing this area.

There are 47 residences and 1 commercial establishment within the 100-year flood plain at the second area. Expected annual damages for the residences is about $30,000. Although flood damages are not excessive evacuation of this area would be difficult. Flood depths on the roadway are 5 and 7 feet for 100 and 500-year floods respectively.

10. Derby. The principal source of flooding in Derby is the Housatonic River. Notable floods have occurred in March 1936, September 1938, January 1949, August 1955 and October 1955. The October 1955 flood of record has a recurrence interval of approximately 100 years.

There are three damage areas on the Housatonic. The first area, located 1.5 miles upstream of Shelton Dam is comprised of 23 cottages on McConney Grove. Nineteen of these cottages are within the 20-year flood plain. Expected annual damages total $45,000 for this area. Even though most of these cottages are used only during the summer months, this can be a significant problem area. Flood depths of 5, 10, and 14 feet for 50, 100 and 500-year events can be expected at the cottages as well as the only access road (unpaved). Due to the type of construction of these cottages their structural stability in the event of a flood is questionable. Therefore, even a 50-year flood presents a potential loss of life situation.

The second damage site in Derby is a large industrial complex on the Housatonic River approximately 1.5 miles upstream of the confluence of the Naugatuck with the Housatonic. Because of the complexity of this site and lack of flood damages it is difficult to assess the flood hazard. Portions of the structure are susceptible to flooding from the 50-year event, while other areas are affected only by the 500-year event.

The third area in Derby is comprised of 5 commercial structures on the Housatonic just downstream of the confluence of the Naugatuck River. First floor elevations of these structures are close to the 100-year elevation and flood depths of 5 feet can be expected during a 500-year flood.

11. Shelton. There are four areas in Shelton subject to flooding. Three of these areas are on the Housatonic, while the fourth is on Means Brook. Notable floods occurred in Shelton in March 1936, September 1938, January 1949, August 1955 and October 1955. With the exception of the August 1955 storm, these floods all had recurrence intervals of less than 50 years.

The first damage area, is approximately 3 miles upstream of Shelton Dam on the Housatonic. The area is comprised of 59 homes and well fields and pump station belonging to Bridgeport Hydraulic Company. Expected annual damages for the residential structures is about $7,000. Although the flood problem at this site does not appear to be critical, the only access road (unpaved) servicing this area would be impassable in the event of a 100-year storm.

The second damage area, is approximately 1 mile upstream of Shelton Dam on the Housatonic. This area is comprised of 61 cottages within the 50-year flood plain and thirty-eight of these cottages are within the 20-year flood plain. Expected annual damages for the cottages total some $130,000. Flood depths of 7 and 11 feet can be expected from 100 and 500-year storms respectively. Similar flood depths apply to the development's only access road. The situation at this area is analagous to the one across the river in Derby. The structural stability of these cottages during flooding conditions is questionable. Therefore, large floods have the potential to result in loss of life.

The third damage area on the Housatonic is located 1 mile upstream of the confluence of the Naugatuck with the Housatonic. There are 11 industrial establishments subject to flooding from a 50-year event. Because of the complexity of this area, it is difficult to assess the flood hazard.

The fourth damage area is located on Means Brook. This area is comprised of 10 commercial structures and a U.S. Post Office. Eight of these structures, including the Post Office, are subject to flooding from a 10-year event. Because these structures are subject to frequent flooding it is believed that their expected annual damages could be substantial.

12. Watertown. Two areas on Steele Brook are subject to flooding. The brook is susceptible to intense and sudden flooding, as a result of the steep sloping terrain of the basin. Additionally, numerous restrictions such as low bridges, overhanging buildings, private dams and sharp bends in the channel all contribute to the flooding problems.

The first area on Steele Brook is approximately 1.5 miles upstream of Pin Shop Dam. There are 5 commercial and industrial structures in this area within the 500-year flood plain.

The second area on Steele Brook is in the area of Heminway Pond. There are 7 structures in this area within the 100-year flood plain. Three of these structures are affected by the 50-year event. The Timex building on Echo Lake Road which would be affected by a 100-year flood may have special significance because it could be involved in defense work. A large flood could have a significant effect on national defense objectives.

13. Torrington. There are three areas in Torrington subject to flooding. Two of these areas are on the West Branch Naugatuck while the third is on the East Branch Naugatuck. The flood of record in Torrington occurred in August 1955. Six lives were lost and damage to industrial structures totalled $7 million while municipal losses totaled $14 million (1955 dollars). In response to this flood, several flood control projects were constructed. Despite these projects, some areas are still susceptible to flooding.

The first area on the West Branch is located approximately 1000 feet upstream of the Corps' local protection project. There are 3 structures affected by the 500-year, 1 by the 100-year event.

The second area on the West Branch is located directly upstream of the Route 272 bridge over the West Branch in Drakeville. There are three residences, a commercial building and a trailer park consisting of 35 trailers, within the 100-year flood plain. Detailed hydraulic information is not available for this area, however, it is estimated that flood waters during a 500-year storm could be as deep as 6 feet at the trailer park. Additionally, ice jams have a history of occurring upstream of this site. In the event of a sudden break in the jam, this area could suddenly be inundated with little warning.

The third area in Torrington is located 1/2 mile upstream of the local protection project on the East Branch Naugatuck. There are 5 structures within the flood plain. Two are affected by the 500-year, 1 by the 100-year, 1 by the 50-year and 1 by the 10-year floods.

ALTERNATIVE FUTURE CONDITIONS

Major uncertainties are always associated with projections of future conditions for a given study area. Criteria used in the projection methodology may or may not prove accurate. However, the combination of expressed opinions, assumptions , and probabilities about the study area produces alternatives that could appreciably affect the directions of future development. The U.S. Water Resource Council, in its Principles and Standards for evaluation of water and related land resources, requires that alternative future conditions be analyzed that are reasonably probable and that, if realized, would appreciably affect plan design or scheduling.

In order to develop plans that would be responsive to both the immediate as well as the short-term and long-range needs of the study area and to the overall goals of the States of Massachusetts and Connecticut, future conditions were projected based upon available planning data and information obtained from various Federal, State, regional and local agencies.

The projections made in the previous section display the most probable future conditions. To determine the flexibility of the various plans developed, higher and lower demands were projected. It was assumed that each water company's projected demand as shown on Table 2 in the Main Report would increase by 20 percent for the high growth scenerio.

In order for one of the water companies to have a 20% increase in total demand, one or more of the factors such as; population served, gpcd, industrial usage or unaccounted for water, has to increase substantially. For example, the Stamford Water Company presently supplies an average of 14.8 mgd, consisting of 8.4 mgd residential-commercial, 2.2 industrial, 1.5 unaccounted for and 2.7 by the utility. A 20% increase in total demand amounts to 3 mgd, which could result from a 150% increase in industrial demand or a 200% increase in unaccounted for water or a 35% increase in the number of people served on a 35% increase in the gpcd or some combination of two or more of these factors. Therefore, it is reasonable to assume that the water companies will not realize more than a 20% increase or decrease in total demand.

As a result of this assumption the total 2000 deficit for Massachusetts would increase by 2.06 mgd and by 5.02 mgd in 2030. For Connecticut the 2000 increase in demand would result in a deficit increase of 14.6 mgd and in 2030 an increase of 29.3 mgd.

To develop a low growth scenario, it was assumed the projected demands would decrease by 20%. The deficits associated with the high, low and most probable scenario's are presented in Table A-18.

TABLE A-18
ALTERNATIVE FUTURE DEFICITS
(mgd)

	MASSACHUSETTS	CONNECTICUT
2000		
Low	0.2	0.2
Most Probable	1.02	2.98
High	3.08	17.6
2030		
Low	2.11	4.2
Most Probable	6.78	19.02
High	11.8	48.3

Another factor that could change the the "most probable" deficits is the elimination of existing supplies. If one of the water supply sources making up a portion of the safe yield of a system becomes contaminated and subsequently eliminated, the projected deficit of that system increases. Many sources throughout the basin have been closed due to contamination, for example the wellfield in Darien used by the Noroton Water Company was closed due to the discovery of trichloroelthylene. Because of color, odor and turbidity problems, the Ridgefield Water Company was ordered by the DOHS to shut down their Round Pond Reservoir. It is not possible to predict which systems in the study area will fail in the future. The 20% increase in demand causes the deficit to increase by a much higher percentage. Therefore, it is reasonable to assume the 20% will account for future system failures.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P. O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

July 5, 1978

Colonel John P. Chandler
Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Chandler:

This is our preliminary fish and wildlife inventory and assessment for the Housatonic River Basin Urban Study, Massachusetts and Connecticut. It is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The Housatonic River Basin contains a variety of fish,and wildlife habitats, which support a diverse population of fish and wildlife species. Habitats include forested hills of the Berkshires in the shouthwestern and northwestern corners of Massachusetts and Connecticut, respectively, lakes, ponds and man-made reservoirs scattered throughout the basin, wetland habitat along the mainstem Housatonic River, abandoned and active farmland in the river valleys, the many cold-water and warm-water rivers, streams and brooks that eventually feed the Housatonic River, and the estuarine portion of the river that extends inland several miles from Long Island Sound.

Species likely to be found in the forested, hilly portion of the basin include the white-tailed deer and coyote. Black bear and bobcat can be found in the more remote northern section of the basin. Birds and mammals frequenting the river valley would include the ruffed grouse, pheasant, woodcock, cottontail rabbit, gray squirrel, red and gray fox and raccoon. Wetlands would support many species of waterfowl, and furbearers such as the raccoon, mink, muskrat, otter, and beaver. Other small mammals, such as mice, moles, shrews, etc., and numerous species of song and other non-game birds, including raptors, would be found throughout the basin habitats.

Major fish species found in the lakes, streams and rivers include brook, brown and rainbow trout, kokanee salmon, smallmouth and largemouth bass, northern pike, pickerel, yellow perch, sunfish, bullhead, suckers, and various minnows. In the estuarine portion of the basin various anadromous species such as the American shad, sea-run brown trout, alewife and blueback herring are found. In addition, one of the major oyster-producing areas in Long Island Sound is the lower Housatonic River. A listing of brid, mammal and fish species found in the Housatonic River Basin is attached.

Both the Massachusetts Division of Fisheries and Wildlife and the Connecticut Department of Environmental Protection conduct fish and wildlife management and stocking programs within the basin. Over 80 ponds and streams are stocked with trout annually in the Massachusetts portion of the basin, and over 75 in Connecticut. Pheasants are stocked throughout the basin in wildlife management areas, state forests, and other suitable areas. Both states have active wild turkey restoration programs in the basin. In general, hunting and fishing opportunities in the Housatonic River Basin are as good as in any other section of either state.

Private conservation organizations active in the Housatonic River Basin would include the Audubon Societies of Massachusetts and Connecticut, which have several sanctuaries located here, such as Pleasant Valley and Canoe Meadow in Massachusetts, and the Sharon Audubon Center in Connecticut. The White Memorial Foundation, located in Litchfield, Connecticut, operates a several throusand-acre sanctuary.

Fish and wildlife resources can be affected directly and/or indirectly, benefically and/or adversely, by proposals for wastewater management, water supply, and flood control. Wastewater management usually takes the form of sewage treatment plants, sewer lines and interceptors. However, it could also involve areawide planning for the treatment of non-point sources of pollution, such as agricultural wastes and stormwater runoff. In general, wastewater treatment projects are usually beneficial to fish and wildlife resources, by reducing and/or treating domestic and industrial discharges. Fish and wildlife resources may be adversely affected by these proposals, however, because of improper siting of treatment facilities in wetlands or productive shallow water habitats, by routing sewer lines through wetlands and water bodies without examining alternative routes or implementing proper construction procedures, or by treating pollutant discharges with excessively high levels of chlorine or other biotoxicants that can in themselves kill or harm aquatic life. Areawide (208) studies are currently being conducted by state and regional planning commissions to plan for the 1983 water quality goals in the Housatonic basin.

Water supply projects are hard to generalize about, since they may take various forms. Water supply reservoirs can eliminate valuable stream and river fisheries, and inundate productive wildlife habitats. These adverse effects can be mitigated by the acquisition and management of additional fish and wildlife habitats. River diversions can be neutral in their effect, or they can be detrimental to fishery resources by withdrawing water needed to provide optimum flows for aquatic life.

Ground water resources may be tapped for water supply, and again could be neutral or detrimental to fish and wildlife resources depending on the effects of withdrawal on surface water bodies and wetlands.

Flood control projects span the range from non-structural measures such as floodplain zoning and floodplain evaluation, to structural methods such as large dams and reservoirs. Effects on fish and wildlife resources depend on the type of project. Non-structural solutions have an indirect benefit in that no fish and wildlife habitat is lost, and acquisition of floodplain habitat or wetlands preserve natural resource habitat. Mitigating features can be incorporated into many projects, and acquisition and management of additional project land can become a part of large projects such as dams and reservoirs. The Fish and Wildlife Service normally encourages non-structural solutions, such as purchasing or obtaining easements of floodplain or wetlands, and when structural solution are necessary, recommends the least damaging proposal that meets the project objective, and mitigating and/or compensating for any unavoidable habitat losses.

We will be pleased to continue working with you on this study as you focus in on specific problem areas and solutions.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor

Attachments

HOUSATONIC RIVER

Americal eel (Anguilla rostrata)
alewife (Alosa pseudoharengus)
rainbow trout (Salmo gairdneri) - Lake Lillinoah - only in spring
brook trout (Salvelinus fontinalis)
brown trout (Salmo trutta)
chain pickerel (Esox niger) - Lake Lillinoah
carp (Cyprinus carpio)
cutlips minnow (Exoglossum maxillingua)
golden shiner (Notemigonus crysoleucas)
bridled shiner (Notropis bifrenatus)
common shiner (Notropis cornutus)
spottail shiner (Notropis hudsonius)
blacknose dace (Rhinichthys atratulus)
longnose dace (Rhinichthys cataractae)
creek chub (Semotilus atromaculatus)
fallfish (Semotilus corporalis)
white sucker (Catostomus commersoni)
creek chubsucker (Erimyzon oblongus)
white catfish (Ictalurus catus) - not common
brown bullhead (Ictalurus nebulosus)
banded killifish (Fundulus diaphanus)
white perch (Morone americana)
rock bass (Ambloplites rupestris)
redbreast sunfish (Lepomis auritus)
pumpkinseed (Lepomis gibbosus)
bluegill (Lepomis macrochirus)
smallmouth bass (Micropterus dolomieui)
largemouth bass (Micropterus salmoides)
black crappie (Pomoxis nigromaculatus)
tessellated darter (Etheostoma olmstedi)
walleye (Stizostedion vitreum)
yellow perch (Perca flavescens)
northern pike (Esox lucius) - Lake Lillinoah

MAMMALS

Virginia Opossum (Didelphis marsupialis)
Common Mole (Scalopus aquaticus)
Hairy-Tailed Mole (Parascalops breweri)
Star-Nosed Mole (Condylura cristata)
Masked Shrew (Sorex cinereus)
Northern Water Shrew (Sorex palustris)
Shorttail Shrew (Blarina brevicauda)
Little Brown Bat (Myotis lucifugus)
Silver-Haired Bat (Lasionycteris noctivagans)
Eastern Pipistrelle (Pipistrellus subflavus)
Big Brown Bat (Eptesicus fuscus)
Red Bat (Lasiurus borealis)
Hoary Bat (Lasiurus cinereus)
Raccoon (Procyon lotor)
Shorttail Weasel (Mustela erminea)
Longtail Weasel (Mustela frenata)
Mink (Mustela vison)
Otter (Lutra canadensis)
Striped Skunk (Mephitis mephitis)
Red Fox (Vulpes fulva)
Gray Fox (Urocyon cinereoargenteus)
Bobcat (Lynx rufus)
Woodchuck (Marmota monax)
Eastern Chipmunk (Tamias striatus)
Red Squirrel (Tamiasciurus hudsonicus)
Eastern Gray Squirrel (Sciurus carolinensis)
Southern Flying Squirrel (Glaucomys volans)
Beaver (Castor canadensis)
White-Footed Mouse (Peromyscus leucopus)
Meadow Vole (Microtus pennsylvanicus)
Muskrat (Ondatra zibethicus)
House Mouse (Mus musculus)
Norway Rat (Rattus norvegicus)
Meadow Jumping Mouse (Zapus hudsonius)
Woodland Jumping Mouse (Nepaeozapus insignis)
Porcupine (Erethizon dorsatum)
Snowshoe Hare (Lepus americanus)
Cottontail (Sylvilagus floridanus)
New England Cottontail (Sylvilagus transitionalis)
White-Tailed Deer (Odocoileus virginianus)

BIRDS

Pied-Billed Grebe
Great Blue Heron "R"
Green Heron "X"
American Bittern "R"
Canada Goose "X"
Mallard "X"
Black Duck "X"
Blue-Winged Teal
Wood Duck "X"
Ring-Necked Duck
Common Goldeneye
Hooded Merganser
Common Merganser
Turkey Vulture "X"
Goshawk "X" & "R"
Sharp-Shinned Hawk "R"
Cooper's Hawk "R"
Red-Tailed Hawk "X"
Red-Shouldered Hawk "R"
Broad-Winged Hawk "X"
Marsh Hawk "R"
Osprey "R"
Peregrine Falcon "R"
Sparrow Hawk "X"
Ruffed Grouse "X"
Bobwhite "X"
Ring-Necked Pheasant "X"
Turkey
Virginia Rail "X"
Sora
Killdeer "X"
American Woodcock "X"
Common Snipe "X"
Spotted Sandpiper "X"
Pectoral Sandpiper
Rock Dove "X"
Mourning Dove "X"
Yellow-Billed Cuckoo "X"
Black-Billed Cuckoo "X"
Screech Owl "X"
Great Horned Owl "X"
Barred Owl "X"
Saw-Whet Owl
Whip-Poor-Will "X"
Common Nighthawk "X"
Chimney Swift "X"
Ruby-Throated Hummingbird "X"
Belted Kingfisher "X"
Yellow-Shafted Flicker "X"
Pileated Woodpecker "X"

Red-Bellied Woodpecker "R"
Yellow-Bellied Sapsucker "R"
Hairy Woodpecker "X"
Downy Woodpecker "X"
Eastern Kingbird "X"
Great Crested Flycatcher "X"
Eastern Phoebe "X"
Alder Flycatcher "X" & "R"
Traill's Flycatcher "X"
Least Flycatcher "X"
Wood Eastern Pewee "X"
Olive-Sided Flycatcher
Horned Lark "R"
Tree Swallow "X"
Bank Swallow "X"
Rough-Winged Swallow "X"
Barn Swallow "X"
Cliff Swallow "X" & "R"
Purple Martin "X" & "R"
Blue Jay "X"
Common Crow "X"
Black-Capped Chickadee "X"
Tufted Titmouse "X"
White-Breasted Nuthatch "X"
Red-Breasted Nuthatch "X"
Brown Creeper "X"
House Wren "X"
Winter Wren "X"
Long-Billed Marsh Wren
Short-Billed Marsh Wren "X" &
Mockingbird "X"
Catbird "X"
Brown Thrasher "X"
Robin "X"
Wood Thrush "X"
Hermit Thrush
Swainson's Thrush "R"
Gray-Cheeked Thrush
Veery "X"
Eastern Bluebird "X" & "R"
Blue-Gray Gnatcatcher "X"
Golden-Crowned Kinglet "R"
Ruby-Crowned Kinglet
Cedar Waxwing "X"
Starling "X"
White-Eyed Vireo "X"
Yellow-Throated Vireo "X"
Solitary Vireo
Red-Eyed Vireo "X"
Warbling Vireo "X"

BIRDS (continued)

Black-and-White Warbler "X"
Worm-Eating Warbler
Golden-Winged Warbler "X"
Blue-Winged Warbler "X"
Tennessee Warbler
Nashville Warbler
Parula Warbler "X" & "R"
Yellow Warbler "X"
Magnolia Warbler "X" & "R"
Cape May Warbler
Black-Throated Blue Warbler "X"
Myrtle Warbler "X" & "R"
Black-Throated Green Warbler "X"
Blackburnian Warbler "X"
Chestnut-Sided Warbler "X"
Bay-Breasted Warbler
Blackpoll Warbler
Pine Warbler "R"
Prairie Warbler "X"
Palm Warbler
Ovenbird "X"
Northern Waterthrush "X"
Louisiana Waterthrush "X"
Yellowthroat "X"
Yellow-Breasted Chat
Hooded Warbler
Wilson's Warbler
Canada Warbler "X"
American Redstart "X"
House Sparrow "X"
Bobolink "X"
Eastern Meadowlark "X"
Redwinged Blackbird "X"
Northern Oriole "X"
Common Grackle "X"
Brown-Headed Cowbird "X"
Scarlet Tanager "X"
Cardinal "X"
Rose-Breasted Grosbeak "X"
Indigo Bunting "X"
Dickcissel
Evening Grosbeak "R"
Purple Finch "X"
House Finch
Pine Grosbeak
Common Redpoll
Pine Siskin
American Goldfinch "X"
Red Crossbill
White-Winged Crossbill
Rufous-Sided Towhee "X"
Savannah Sparrow "R"
Vesper Sparrow "R"
Slate-Colored Junco "X"
Tree Sparrow
Chipping Sparrow "X"
Field Sparrow "X"
White-Crowned Sparrow
White-Throated Sparrow "X"
Fox Sparrow
Lincoln's Sparrow
Swamp Sparrow "X"
Song Sparrow "X"

"X" = breeding

"R" = Listed in "Rare & Endangered Species of Connecticut and Their Habitats".

APPENDIX B

PLAN FORMULATION APPENDIX

PLAN FORMULATION APPENDIX

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

General

The plan formulation documented in this appendix represents the planning process which led to the plans for water resources management in the study area. The appendix contains information showing the formulation, assessment, and evaluation of alternative water resources plans utilizing the data contained in Appendix A, "Problem Identification" and other appendices accompanying this report, and provides a description of the iterative process utilized in the development of detailed plans. In addition, the appendix summarizes the various interactions that occurred during the planning process and describes their effects on the study outcome.

Study development involved analysis of alternative water resources plans through repeated iterations of four functional tasks: problem identification, formulation of alternatives, impact assessment and evaluation. Analysis and screening of alternatives, through reiteration of the plan formulation process, resulted in plans which were considered to best reflect public desires and to satisfy the planning objectives developed for the study area.

Formulation and Evaluation Criteria

Criteria, including technical, economic, environmental, social and other considerations, permit formulating alternatives that respond directly to the problems and needs of the study area.

Given finite amounts of time, money, and human resources, evaluating all possible alternatives to the same degree of technical detail would be an insurmountable task. Thus, abbreviated planning methods were used in determining the most viable alternatives. These methods are more fully explained in the following sections. The number of alternatives were refined to a workable level without disregarding the problems and needs of the study area.

Technical Criteria. The following technical criteria were adopted from appropriate engineering regulations, manuals, pamphlets and technical letters, and supplemented by engineering judgement and technical experience.

• Water Supplies would satisfy the requirements of the Safe Drinking Water Act, Public Law 93-523.

• Pumps and transmission mains would be sized to accommodate projected 2030 demands.

• Plans would be technically feasible based upon appropriate engineering standards and guidelines.

. Flood protection plans would protect their specific areas without creating adverse effects on downstream reaches.

. Plans of protection for commercial/industrial areas would provide against a design storm equal to the 100-year Flood.

Economic Criteria applied in the formulation and evaluation of alternatives are summarized as follows:

. Total beneficial contributions (economic and nonmonetary) must exceed total adverse contributions (economic and nonmonetary). A plan must produce net National Economic Development (NED) benefits unless the deficiency is the result of economic costs incurred to obtain positive Environmental contributions.

. Each project purpose must provide benefits at least equal to its Separable cost.

. The scope of development is such as to provide maximum net benefits except as modified for Environmental and social well-being concerns.

Benefits and costs are expressed in comparable quantitative economic terms to the fullest extent possible. Annual costs were based upon a 50-year amortization period and an interest rate of 7 3/8 percent. Annual charges also include the cost of operation and maintenance and major replacements. The costs of alternative plans of development were based on survey scope plan layouts and estimates of quantities at an Engineering News Record index of 3500.

Environmental Criteria and Social Considerations. The following environmental criteria were considered in formulating alternative plans.

. Analysis of the environmental impact of any proposed action.

. Identification of any adverse environmental effects that should be avoided should the proposal be implemented.

. Evaluation of alternatives to the proposed action.

. Determination of the relationship between local short-term use of man's environment and the maintenance and enhancement of long-term productivity.

. Accounting of any irreversible and irretrievable commitment of natural resources and biological systems that would be involved in the proposed action should it be implemented.

The following were also considered:

. Management, protection, enhancement, or creation of areas of natural beauty and human enjoyment.

. Management, preservation or enhancement of especially valuable or outstanding archaelogical, historical, biological and geological resources and ecological systems.

. Enhancement of quality aspects of water, land and air, while recognizing and planning for the need to harmonize conservation of the resources with the land use objectives of productivity for economic use and development.

. Development and use objectives which minimize or preclude the possibility of undesirable and irreversible changes in the natural environment.

The following social considerations were also considered in formulating alternative plans:

. Pubic health, safety and social well-being, including possible loss of life.

. Preservation or enhancement of social, cultural, recreational, archaeological and historical, and aesthetic values in the study area.

. General public acceptance, as determined by coordination with appropriate Federal, State and local agencies, organized groups and individuals, and especially with both the local sponsor and study area interests.

MANAGEMENT MEASURES

Potential Resource Management Measures

General. The inability of the existing water supply systems to meet projected demands has created problems in the study area with presently developed supply sources. Since some present and future municipal and industrial water requirements exceed the capacity of existing available supplies, management measures must consider reducing these demands and/or developing additional sources. Several alternative measures to satisfy the problems and needs of study area communities are possible however, some of the measures are either impractical, uneconomical, or both. There are two broad categories of possible solutions. The first is measures to reduce consumption. The second is measures to increase supply. The former category includes those management measures generally classified as nonstructural while the latter category includes various structural measures to obtain supplemental water supplies. Combinations of both nonstructural and structural measures are also possible.

Management Measures. In formulating alternatives, the whole array of both nonstructural and structural management measures were investigated. Table B-1 presents a listing of potential management measures considered in this study. Subsequent paragraphs describe each measure and the rationale used in the initial screening process.

TABLE B-1
WATER SUPPLY MANAGEMENT MEASURES

No Action Program
Nonstructural Measures
1. Water Conservation
2. Weather Modification
3. Direct Wastewater Reuse

Structural Measures
1. Surface Water Resources
2. Groundwater Resources
3. Importation
4. Dual Water Supply Systems
5. Desalination

No Action Program. This measure assumes that maintenance of the base condition for water supply management in the study area would continue. The measure further assumes that no action would be taken, by water supply agencies serving study area communities, to construct new facilities or to reduce residential water consumption and commercial and industrial demands in the face of increasing water requirements. If no action were taken to increase supply or curb demand, 19 systems in the study area would experience water deficits prior to the year 2030.

A No Action Program would produce significant socio-economic and environmental impacts within the study area in addition to not satisfying the planning objectives for municipal and industrial water supply management. Use of this measure, therefore, does not offer a realistic solution to water needs of the study area and was therefore dropped from further evaluation in the formulation of alternative plans.

Nonstructural Measures

Water Conservation. Historically municipal and industrial water demand has increased annually primarily due to increased industrial output, greater numbers of and a wider distribution of, water consuming appliances, due to increased populations and to overall higher standards of living. Industrial, commercial and residential use accounts for almost 100 percent of the treated water used in urban areas throughout this country.

When the demand for water increases, the usual response is to construct new waterworks facilities. However, an alternative approach is to reduce demand in conformance with available supplies. Proper management techniques can slow, and sometimes even stop, increases in water usage.

The following paragraphs provide a summary of several different techniques investigated in this study for managing these water demands.

a. Metering: The installation of meters that measure the amount of water used by consumers has been shown to be effective, to varying degrees, in reducing demand for water supply. With metering, water customers are charged for the quantity of water actually used, instead of being charged a flat rate or some other pricing arrangement for some specific time period regardless of the quantity used.

Use of metering appears, therefore, to present a good opportunity for conservation of this important resource. In the Connecticut portion of the study area, however, application of this technique is quite limited due to the extensive use of metering by existing water supply system.

Most of the water systems in the Massachusetts portion of the basin are not metered. Complete metering of services within Massachusetts could have a substantial effect on existing water usage.

b. Pricing Structures: Rates may be charged in a number of different ways. Some alternative pricing policies are:

. Spatial differentation of prices (different charges for different areas of the community based on the cost of providing service to each area).

. Seasonal prices (higher prices during times of higher demand).

• Decreasing block rates (users are charged decreasing amounts for incremental increased usage).

• Average variable cost pricing (a quantity charge would cover only operation and maintenance costs; a flat rate charge would cover the fixed costs such as debt services).

• Increasing block rates (users are charged increasing amounts for incremental increased usage).

c. Water Saving Devices: The principle behind the use of water saving devices is to reduce flows from showers, lavatories, and toilets to the minimum necessary to perform their intended purpose. This can be accomplished either by adding flow reducing devices to existing fixtures, by replacing these items with new fixtures designed to reduce flows, by reducing service pressures with the use of pressure regulating devices, or by replacing inefficient automatic dishwashers and clothes washers with water conserving models. Some of the devices which have the most potential for reducing water use are listed below:

• Water Saving Toilets

• Reduced flush devices (toilets dams, displacement bottles)

• Flow limiting shower heads

• Water conserving dishwashers and clothes washing machines

• Flow control devices for faucets

• Pressure reducing valves (to reduce unnecessarily high system pressures)

d. Conservation Education: A basic solution to the problem of reducing waste in water consumption is modification of water use attitudes and habits. This can be accomplished in part through education and information campaigns directed toward the consumer. As in the case of water saving devices, this technique is aimed at reducing waste by the residential user. The success of these campaigns is based solely on the voluntary efforts of the consumer to conserve water.

Public educational programs instituted throughout the country have included the following items:

• Printed inserts and brochures included with water bills.

• Posters hung in classrooms, on public transportation vehicles and on sidewalk trash receptables.

- Reminder items such as buttons, T-shirts, litter bags and bumper stickers.

- Radio and television advertising.

- Contact with community groups through the use of public speakers, film presentations, or slides.

- Education in the schools to change attitudes on water use.

- Contests for water conservation slogans or posters.

- Test programs aimed at water conservation such as installation of watersaving devices.

e. Institutional Restrictions: Institutional restrictions have been traditionally regarded as administrative and legislative policy controls which can be implemented by water suppliers and government agencies to insure public welfare and security during times of water supply shortages. They include any legally enforced restriction on the use of water. It is equally important to consider institutional restrictions as methods of conservation to prevent shortage as well as to survive during a period of reduced supply.

Some institutional restrictions on water use applicable to the study area are:

Restrictions on Domestic Water Use - Mandatory conservation programs have typically been directed toward the residential customer. These restrictions are effective first, because residential use is generally the largest single use of municipal water supplies, and second, because lawn watering, car washing and swimming pool filling can easily be eliminated because of their high visibility and low priority in times of shortage. These outside water uses are coincident with a variety of warm weather practices which create high-peak demands during periods when supplies are most likely to be lowest.

Water Rationing - This technique is the most severe method of reducing consumption. It involves the allocation of water to customers with stiff penalties for exceeding allowable water use. Water rationing is adopted only in cases of extreme shortage.

Building and Plumbing Code Restrictions - These restrictions, requiring the use of water saving devices in new construction such as shallow trap toilets and flow restricting shower heads, can result in significant savings in the future with little or no inconvenience to the consumer, Building code restrictions, in addition to requiring water conserving fixtures in the home, can also set limits on service pressures, thereby requiring pressure reducing valves on some services.

Control of Water used for Maintenance - Sanitary procedures involving flushing sewers and washing buildings, streets, and sidewalks can be controlled through regulation during periods of shortage. It is possible that chlorinated river water could be used for these purposes.

Inspections - Municipal or State inspections of the premises of water system customers for leakage and obvious waste is a measure that can be taken during extreme shortage. The potential for reducing consumption on a metered system with this technique is limited.

Fire Hydrant Use Restriction - There is indication that stiffer penalties for illegal use of fire hydrants may result in less unauthorized use through vandalism and illegal connections. In some high-crime neighborhoods, safety harnesses are installed on hydrants to help eliminate this problem.

Landscape Watering - Of the outside domestic uses, landscape watering has the greatest potential for demand modification. This type of irrigation represents approximately 3 percent of the average household use in this area of the country. Much attention has been given to this subject in California conservation programs where irrigation accounts for nearly 50 percent of domestic use. Some of the lessons learned from their experiences are worth mentioning. Effective soil preparation allows plant areas to absorb and retain the moisture needed for plant growth. Deep, slow watering during the late evening and early morning hours is more effective than heavy watering during the heat of the day. California programs have made a strong case for the use of native drought resistant plant materials. This can be an important consideration even in New England.

f. Control of Water System Losses: Water system losses can result from leakage, unmetered connections, fire flows, and illegal uses. The control of these losses increases the operating efficiency of the water system. Unmetered connections are generally associated with municipal uses such as service to municipal buildings, sewer flushing, and street cleaning.

Control of system losses can be accomplished through leak detection and repair, the metering of all uses, and the reduction of illegal water use. A leak detection program involves prompt control and repair of visible leaks as well as detection and repair of hidden leaks through the use of modern sensing equipment. The placement of meters on all services allows the water supplier to better account for system performance and to approximate other losses which are not meterable. The illegal opening of fire hydrants is a major system loss in some areas. This can, however, be reduced through the institution of stiff penalties and through the use of security devices which make fire hydrants more tamper-proof.

Weather Modification. The primary source of water used for public and private water supply in Connecticut and Massachusetts, as in most humid areas, is precipitation falling directly on the areas concerned. It follows then that if precipitation can be increased in a regulated manner, the water supply can also be increased. To this end, several major agencies such as the National Oceanic and Atmospheric Administration (NOAA), the United States Bureau of Reclamation, the American Meterological Society, and the National Science Foundation are investigating ways of productively modifying natural precipitation patterns. The primary focus of research is in the area of cloud-seeding. Other fields of interest are long-term seasonal precipitation forecasting and fog drip augmentation. Since little work has been done on the latter two, and what little has been accomplished is not applicable to the study area, only the process of cloud-seeding will be reviewed in this section.

Simply stated, rain falls from clouds when water vapor in the cloud condenses around nuclei and forms rain drops large enough to overcome frictional resistance to falling. In technical terms, this process is the conversion of the water vapor from a state of colloidal stability to one of colloidal instability. The concept of artifically induced precipitation by cloud seeding refers to the introduction of particles of foreign substances, such as dry ice and silver iodine into clouds to serve as condensation nuclei. Theoretically, this action will result in condensation of the water vapor and consequent precipitation. In short, it is scientific rain-making.

The testing of the engineering and economic feasibility of this theoretical process has been concentrated in experimental projects in the Rocky Mountain and Upper Great Plains regions. Evidence gained through NOAA research suggests that winter cloud systems over Lake Erie may be modified to produce additional precipitation. A cost-benefit study was performed for the Connecticut River Basin, but this study was in design only with no actual expermimental work involved. Most information regarding the potential of cloud-seeding in the eastern United States is derived from commercial cloudseeding operations.

Some of the findings resulting from these studies and experiments are summarized below:

- The state of the art is such that most researchers look upon the potential of increased precipitation through cloud-seeding with an air of cautious optimism. Study to date, however, has provided little more than a beginning to the solution of many of the problems involved in weather modification.

- Cloud-seeding is impractical during severe drought conditions when water shortages are most critical. The first requisite for cloud-seeding is the presence of clouds, and droughts are notable for their lack of clouds. Present technology is not even remotely capable of producing clouds by weather pattern modification. During a temporary interruption of drought conditions, clouds may form over an area. Even under these conditions, however, cloud-seeding would not appreciably alleviate water supply problems since most precipitation would be in all likelihood taken up immediately by plants and soil. It would be apparent then that water shortages in periods of drought cannot be solved by cloud-seeding. Any substantial seeding-induced precipitation would have to be produced during nondrought conditions with abundant moisture in the atmosphere.

. There are many problems that must be solved before substantial technological breakthroughs result. One of the most critical is the inability of researchers to satisfactorily define optimum cloud conditions and seeding techiques and to predict seeding results accurately. In other words, there is an inadequate understanding of the basic cloud processes which determine: a) the "seedability" of a cloud or cloud system, and b) the proper seeding treatment to stimulate rainfall production efficiently in a potentially seedable cloud.

Another problem is the possibility of undesirable effects of seeding. Indiscriminate seeding might increase soil erosion and sedimination in streams through intensification of the normal rainfall rate of natural storms. There is the possiblity also that artificial seeding of clouds might in fact reduce the natural rain producing capacity of the clouds.

. Estimates of the feasibility of cloud seeding in the eastern part of the country, including New England, are vague and poorly defined. Most recent cloud-seeding research has been conducted in the western states. Atmospheric scientists have cautioned that results of seeding experiments in one area of the country must be viewed with caution when applied to other areas characterized by different topography and climate. It is apparent that much research needs to be done in the eastern part of the country. There is data available for parts of this area from commercial cloud-seeding operations. However, these operations were not performed under proper scientific and statistical control procedures and any data gathered in such a manner must be used and interpreted with care.

Research has continued to improve the state of the art of weather modification by cloud-seeding and other means. However, weather modification is still an inexact science at best. Studies are unable to predict optimum cloud conditions and seeding results with any degree of accuracy. Thus, at this time, weather modification operations to augment water supplies in the study area do not appear to provide a viable solution to water supply problems of the study area.

Direct Wastewater Reuse as a Muncipal Supply. Direct wastewater reuse involves returning the effluent from wastewater treatment facilities to municipal or industrial supplies. For use in a public water supply system, the treated wastewater must be of high enough quality so that water quality aspects of the existing supply will not be adversely affected by mixing the two waters. Thus the effluent must be safe for human consumption, which could only be achieved through the use of advanced, sophisticated treatment techniques.

Direct wastewater reuse, especially in industrial process application, as been economically successful in many sections of the country. The Bethlehem Steel Company in Baltimore, Maryland currently uses about 120 mgd of treated municipal effluent from Baltimore in its quenching and cooling processes. The Dow Chemical Company uses treated wastewater from the City of Midland, Michigan for use in its cooling water and fire protection system. In Amarillo, Texas effluent from the municipal wastewater treatment facilities is used as cooling water and boiler make-up water for industries located in that city.

Other uses to which treated wastewaster has been applied include irrigation of both crop land and lawns, as a freshwater barrier against salt water intrustion, and in some cases as a source of supply for formation of recreation lakes and ponds.

Direct reuse of wastewater effluent as a public water supply, however, has not been utilized to a large degree. Advanced waste treatment research and development programs at the Federal level are continuing and pilot plant studies such as the noted Lake Tahoe project are apparently meeting with success in producing a high quality effluent.

Health officials feel that many questions remain unanswered which must he fully investigated if renovated wastewater is to be considered for drinking water purposes. Much research remains to be initiated in several areas, including studies on viruses and their relation to and removal from wastewater. Studies on health effects of other microorganisms and chemicals present in treated wastewater and studies into increasing the reliability of the technology available for wastewater treatment are also required.

The future of direct wastewater reuse, particularly in industrial applications, seems promising. In fact, industry already appears to be moving in the direction of greater recycling. Use of renovated wastewater as a regular domestic supply, however, requires full results of proposed research. Until such research is completed, wastewater reuse as a municipal water supply is not a viable alternative to meet water supply needs in the study area. Renovated wastewater should not be considered for drinking water needs unless there is no other practical choice.

Surface Water Resources. Surface water development may take one of three forms: continuous draft, selective draft, and impoundage. For communities situated on or near streams, ponds, or lakes of sufficient flow or capacity, continuous draft may be used to obtain water year-round. If a selected stream is of insufficient size to meet year-round needs, or if water quality variations are a consideration, selective draft during high flows may be utilized. In either case, for smaller streams it may be necessary to construct a diversion dam to assure that the intake pipe is submerged during withdrawal of water. Water drawn from larger lakes and streams must generally be treated before use.

Impounding a stream to create a reservoir may be the most desirable method of supply. Generally, impounding reservoirs are built in sparsely settled regions on upland streams, so that water drawn from them is relatively pure and can be supplied to the community by gravity. Impounding reservoirs could be of sufficient capacity to assure adequate supply during dry periods, and are generally large enough, with water of high enough quality, to require minimum treatment when considered as part of a municipal water supply system.

Groundwater Resources. Groundwater storage is much greater than all artificial and natural surface storage in the United States. Wells are commonly used to collect groundwater for use in water supplies. The five types of wells generally in use are dug, driven, bored, drilled and gravel packed wells. Dug wells and driven wells are generally used for shallow depths, dug wells being lined or unlined depending on the material excavated, and driven wells restricted to use in relatively shallow sand formations. In soil that is sufficiently cohesive to prevent serious caving, wells are bored with augers by hand or machinery. Drilled wells are the most commonly used type, especially for wells of greater depth than feasible for the other types. Drilled wells are lined with a casing grouted in place for sanitary protection, with a strainer at the bottom of the well to keep out unwanted materials. Gravel wall wells are drilled with a larger hole, and an envelope of gravel is placed outside the well screen to increase the effective diameter of the well and improve the well's hydraulic characteristics.

Water supplied by wells is generally less likely to need treatment than surface water, and is considered to be less expensive to develop in most cases.

Importation. This technique involves the diversion of water, either groundwater or surface water supply, from watersheds outside the basin to augment existing water supply resources. In some cases the diversion would be possible from currently developed sources that are underutilized presently and are expected to remain so over the long term. In other cases, the diversion would be made from presently undeveloped resources to meet the water supply needs of study area communities.

Dual Water Supply Systems. An alternative which has been receiving attention of late has been the use of dual water supply systems. In these systems, a hierarchy of water supply would be established whereby higher quality supplies could be used to furnish a potable source for drinking, cooking, dishwashing, cleaning, bathing and laundering. All other uses could be furnished by a second supply of lesser quality.

Two general methods have been suggested for such a dual system. The first is the possibility of recycling at the point of usage. Under this scheme, drinking, washing and bathing water would undergo treatment and then be further utilized for toilet flush water and outdoor uses. It is estimated that such a system could reduce domestic water use by as much as fifty percent. Various systems for inhouse reuse or for outdoor usage have been proposed and some are being marketed on a small scale.

Advantages of this system, beyond potable water consumption decrease, are the reduction in wastewater volume, sewer pipe, pumping and treatment requirements. Disadvantages to this alternative lie with its limited application and accompanying operational experience, potential problems of odor and other aesthetic considerations. Health officials, in general, have not expressed their acceptance or rejection of such systems. However, their general apprehension in introducing less than potable water into the home environment could also reasonably be expected with regard to any system of this nature.

The second method which has been suggested for delivering higher and lower quality water for various uses would require a second distribution system. This second distribution system would carry river water or even sea water to supplement the high quality primary supply source.

Two methods of providing the second (lower quality) distribution system could be employed. The first would involve installation of the entire system immediately. The second and more practical method would be an incremental approach wherein secondary systems are installed in new or replacement buildings above a certain size.

The high capital costs of providing dual water supply systems to furnish a potable source for both drinking, cooking and other domestic uses and for lesser quality needs precludes its use in the study area. Potential health problems associated with the use of such systems are also a basis for rejection.

Desalination. Desalination, the process in which brackish and saltwater is converted to fresh, is currently being used in some parts of the world as a viable, economically feasible sources of freshwater. This process thus was considered for its potential as a future alternative solution to the water supply needs of Connecticut.

The conversion of saline to freshwater can be accomplished through one of four major processes: distillation-evaporation, membrane separation, crystallization, and chemical differentation. A descriptive summary of each process is given below.

a. Distillation-Evaporation: In this process, water containing salt or other impurities is heated and vaporized. The water vapor, free from the salt and other solids which remain behind as the water boils, is then condensed and collected. The system is basically a simple one requiring only a source of heat energy to boil the water, a method of cooling the water vapor (condensation) and various kinds of plumbing and receptacles for the transfer and storage of the water.

Since distillation, by its nature, results in the complete separation of the water vapor from the dissolved salts of the influent, the process produces freshwater of exceptional purity. Because this method removes the water from the salt, rather than vice versa, the quality of the influent is not critical and the system works equally well on water with a high salt content as on only slightly brackish water, For these reasons, among others, distillation is the oldest and best known process of desalination.

b. Membrane separation: Desalination by the membrane process is based upon the ability of thin membranes to pass molecules of pure water and retain the ions of salts and other dissolved solids. There are three basic variations to this concept: electrodialysis, transport depletion, and reverse osmosis. The first two variations depend on the electrical properties of the ions involved, while the third depends on a pressure differential existing across the membrane. Of these three variations, the electrodialysis and reverse osmosis processes are the most well established, with many commercial installations throughtout the world.

In contrast to distillation, the membrane process separates the salt from the water rather than the water from the salt. Each stage of the electrodialysis process removes slightly less than fifty percent of the dissolved solids in the water being treated. The more saline the water, the more stages are needed and hence more energy is consumed. For this reason, electrodialysis and other variations of the membrane process are more economical when used with brackish water with a salinity of between 5,000-10,000 mg/1, as opposed to more saline water. The water can then be refined in stages to the desired degree of purity.

c. Crystallization: This process relies primarily upon the fact that as water freezes, the ice crystals reject ions of salt. Saline water is frozen and the crystals of pure ice are then skimmed or removed for later use from the still liquied brine. A second method of separation by crystallization employs the hydrate process, which is the formation of a crystalline substance by the combination of water with low molecular weight, hydrocarbons or their derivatives. Like ice crystals, these hydrates reject salt ions. It takes less energy to freeze water than it does to boil it, thus this method has an advantage over distillation in that it consumes less energy. The crystallization process has not been widely used; however, further research into its effectiveness is continuing.

d. Chemical Differentiation: In this process, either the water or the dissolved salts are made to undergo chemical reaction to form a substance which can be easily separated from the untreated water. Ion exchange, a method by which the saline water is passed through treated resin and the salt ions selectively removed, is the most widely used method of chemical desalination.

The efficiency of ion exchange decreases with time as the "holes" in the resin become filled with salt ions. Once the resin is saturated, the operation must be closed down and the resin regenerated. For these reasons, the process has had only local exposure and small volume use.

Present Applications: Sea water can be considered for all intents and purposes an unlimited source of freshwater once the technology of desalination is refined to a point where it is economically feasible. To this purpose, the Federal Government, through the Saline Water Conversion Program, administered by the Office of Water Research and Technology (OWRT), has promoted extensive study and research into the problems of desalination. Several model and testing plants and facilities have been constructed to aid in these studies. The research to date concludes that of the four main processes discussed above, distillation and membrane separation are best suited to large capacity plants. Economic considerations dictate that distillation is best suited for sea water and electrodialysis or reverse osmosis for brackish water.

In 1977, about 1500 land-based desalting plants were providing 24,000 gallons per day (gpd) or more; and more than 350 plants, producing over 1 million gallons per day (mgd) were operating or under contruction worldwide.*

Plants are generally located in arid regions where conventional water sources are high cost or unavailable. Principal areas of use are in the Mid-East and Caribbean tourist islands. In the United States, desalting for water supply has thus far been limited to smaller installations with aggregate capacity of only about 120 mgd, compared to total freshwater requirements in the 350-450 billion gallons per day range.

The largest municipal desalting plant in the United States is a 2.6 mgd distillation process in Key West, Florida. Largest in the world is a French-built, 30 mgd distillation plant, constructed in Kuwait.

The cost of freshwater produced by desalination depends upon the capacity of the plant, the type of process used and the type of energy source used. In general, the larger the plant capacity, the less the cost per unit quantity of water. As has been mentioned previously, distillation is more economical for the desalting of sea water, while membrane processes are better for brackish water. The cost of water from nuclear-fueled plants is approximately 10 percent less than from fossil fuel plants with a large capacity (more than 100 mgd).

Recent cost of desalting sea water are about $4-6 per thousand gallons. This estimate is based upon an output capacity of 1 mgd, an amount representative of many plants currently in operation. Desalination

*Desalting Plans Inventory Report #6, U.S. Dept. of the Interior, October 1977.

of brackish waters by membrane processes is less costly than for sea water but is still in the range of $1 per thousand gallons. Both of these costs have to be weighed against the cost of water from conventional sources, which is up to 40 cents per thousand gallons.

Desalination by various processes is already feasible in parts of the world where natural water supplies are either scarce, of poor quality or completely unavailable. In these areas, the relatively high costs of water produced by desalination are justified. When larger capacity plants are designed and in production the cost of desalination will likely be reduced, but even at a 50 percent reduction from present costs, desalination is not competitive with present cost of developing natural surface and groundwater supplies.

Aside from the economic costs involved with desalination, OWRT is also investigating the potential hazards to the environment. In considering placement for any type of desalting plant, environmental factors are as important as any other factor. Pure water is not the only product. A plant will produce extremely concentrated brine as an effluent, plus any waste emission from the power source, such as soot, heat, smoke, toxic gases, etc. So far as brine is concerned, the brine from distillation plants is of high temperature, higher chloride content and may contain concentrations of copper, all of which may prove injurious to the environment. Special design procedures would be required in the cases of estuaries or areas with restricted water interchange, as many life forms present might be adversely affected. Two land methods of disposal have been studied: (1) evaporation to dryness; and (2) deep-well injection. Evaporation is expensive, though this varies with land costs. It is now quite costly in urban areas. Injection method costs are estimated at 25 to 70 cents per 1,000 gallons of brine. Such costs must be added to plant production and distribution costs to arrive at a true cost of water with this technology. At present OWRT is investigating other methods of brine disposal.

Several constraints characterize present desalting operations. The most important are high total annual costs in comparison with conventional water sources, the need for large plant size to take advantage of economies of scale, and the problems of brine disposal. These will become less restrictive in the future, when desalination may prove to be an attractive supplement to conventional water sources in coastal areas. For the short term, however, desalination is not a viable alternative source of water in Connecticut. When and if the technology and efficiency of this process is refined so that it is economically and environmentally competitive with other methods of supplying water, its feasibility can be re-evaluated.

Preliminary Screening. The results of the preliminary screening and evaluation process used in the first phase of plan formulation for water supply management in the study area are illustrated in Table B-2. During the initial iterations of the planning process, potential measures were evaluated with regard to 1) achievement of planning objectives, 2) cost of implementation, and 3) intangible advantages and disadvantages including social and environmental acceptability.

These investigations indicated that only water conservation among the nonstructural measures and surface water, groundwater and importation development of the structural measures were considered for further evaluation. The No Action Program was not considered an appropriate measure warranting further evaluation.

TABLE B-2
PRELIMINARY SCREENING OF MANAGEMENT MEASURES

POTENTIAL MEASURE	FURTHER EVALUATION WARRANTED	EVALUATION CRITERIA NOT MET
No Action Program	No	3, 4
Nonstructural		
Water Conservation	Yes	
Weather Modification	No	1, 2, 4
Direct Wastewater Reuse	NO	1, 2, 3
Structural		
Surface Water	Yes	
Groundwater	Yes	
Importation	Yes	
Dual Water Supply Systems	No	1, 2, 3
Desalination	No	1

Evaluation Criteria

1. Economic feasibility
2. Engineering practicality
3. Social acceptability
4. Adequate solution

ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING

General

As a result of the initial screening of potential water supply management measures, those considered for further evaluation were analyzed to determine their applicability in management plans to meet study area needs. Each measure was investigated to determine its economic, environmental and social acceptability and also to determine its response to fulfillment of study objectives.

Various surface water reservoir and groundwater aquifer sites were studied and evaluated based upon their ability to satisfy the water supply needs of existing systems serving the study area's communities. Developed and undeveloped supply sources identified in prior studies by others, were screened against economic, environmental and social acceptability criteria and utilized in the development of alternative plans. Only those sites providing adequate quantities of either surface water or groundwater were retained for alternative plan development.

The following sections present information on applicable water supply management measures considered toward the development of intermediate plans.

Nonstructural

Water Conservation

The five techniques suggested for modifying water demands in the study area, and considered applicable as the result of the initial screening, focused primarily on reductions within the residential/ commercial use category. This category accounted for a significant percentage of the study area's publicly-supplied water in 1980. Water use by the residential sector will fluctuate significantly depending on the type and location of the home and individual user habits. However, general patterns of residential water usage can be estimated despite variation in specific use patterns.

Typical residential water use can be broken down in the following approximate proportions:

RESIDENTIAL WATER USE

Component	Percentage
Toilet Flushing	41
Bathing	37
Cooking and Washing	9
Drinking	5
Clothes Washing	4
Lawn Watering	3
Car Washing	1
Total	100

A study was conducted to estimate the effectiveness of the various demand modification techniques in altering residential usage and to determine their feasibility and suitability in the study area. Since water associated with toilet-flushing and bathing constitute about 75-80 percent of all water used inside the home, these functions were the primary targets of water conservation study efforts. The following paragraphs describe the techniques investigated and present information used in their evaluation. Each of the techniques may be used singularly or in combination to achieve reductions in total water used.

Pricing Policies. The price charged for water is generally considered to offer the greatest potential as a demand modification technique. Judicious application of the various pricing policies discussed in the previous section was considered to offer significant reductions in water consumption. However, studies conducted for the New England area indicate that due primarily to the low cost of water in the total per capita budget, pricing does not have a significant affect on residential usage. Raising the price of water substantially above the highest prices currently charged in order to control demand would lead to water revenues significantly exceeding the cost of service. Under such circumstances, implementation of an equitable rate structure is difficult to conceive and would be expected to be socially unacceptable. For these reasons, pricing policies were not considered for further evaluation in the development of alternative water supply plans for the study area as other techniques were considered more effective.

Water Conservation Education and Water Saving Devices. While water conservation education and water saving devices have been discussed separately, in practice their effects cannot be analyzed independently since these two techniques are generally undertaken together. Thus, they were evaluated jointly, and estimated reductions were based on the application of both demand modification techniques simultaneously.

Maximum demand reductions attributed to a joint education/devices program have been estimated in theoretical studies at about 35-40 percent during a drought. These figures assumed an aggressive program of installation of devices, and an active public involvement program. Information from actual case studies of these types of programs shows much smaller reductions than the previous estimates. Reductions in demand vary with each system depending on the number of residential customers in the study area. The major difference is probably the result of the following actual programs relied on education and change of habits to achieve water savings rather than wholesale replacement of major appliances, which was not shown to be cost effective. Also, actual data showed that not all the devices distributed were installed, and not all of those installed were maintained properly. Thus, not all consumers changed their water use habits.

Institutional Restrictions. Other studies have reported that restrictions of the types mentioned in the preceding section of this report could be expected to produce 5-10 percent reductions in overall water demand. However, data obtained from actual case studies show that restrictions alone could be expected to produce a 4 percent reduction in water demands by the year 2030. The case study conclusion was based on building code restrictions and did not assume water use restrictions on lawn sprinkling, car washing, and swimming pool filling which earlier reports had indicated would likely be implemented for several weeks each year.

The estimated 4 percent reduction is based on the understanding that this type of restriction is readily implementable and could be effected even if less publicly acceptable measures such as bans on outdoor water use were not implemented. In the past, these latter measures have been implemented only during periods of emergency or severe shortage, so that their regular use in reducing future water demand was not assured.

Leak Detection. A program of leak detection and repair would be one of the most effective ways to control water system losses in the study area because the municipal systems involved are almost completely metered. Other studies have estimated a 5-10 percent reduction in water demand with implementation of a comprehensive leak detection and repair program. However, in systems where total unaccounted-for water usage is under 15%, the costs associated with such a leak detection and repair program are prohibitively high. It is reasonable to assume that all unaccounted for water over 15% can be saved through a leak detection and repair program.

Metering is the means by which water utilities measure the quantity of water distributed from their water supplies to their customers. In general, consumers in non-metered areas usually consume more water than those in metered areas. In a comparison metered customers used about 15 to 20 percent less water than unmetered customers.

Though metering is not viewed as a direct means of reducing water use, utilizing it in a comprehensive water conservation effort can prove to be very beneficial for it provides a basis for other conservation measures such as leak detection and repair.

It is assumed that all unmetered communities can save 15 percent of their demand through 100 percent metering.

Comprehensive Program of Water Conservation. The combined effect of implementing a comprehensive demand modification program in the study area consisting of 1) water conservation education and installation of water-saving devices, 2) institutional restrictions principally concerned with building code changes, 3) leak detection and repair programs, and 4) metering will reduce projected water demands in the year 2000 and in 2030. This measure was, therefore, carried forward in the development of alternative water supply plans for the study area.

Structural

Development of surface water supply sources to meet study area needs centered on an evaluation of sites identified in prior studies conducted by and for the States of Connecticut and Massachusetts. The amount and level of detail of the initial data available from each State was vastly different. Therefore the screening process was different and as a result the alternative plans for each State will be discussed seperately.

Surface Water Resources. All potential impoundment sites throughout Connecticut were identified and investigated by the State. Many sites were eliminated from further study as potential water supply sources for one or more of the following reasons:

1. Sewage discharge in the watershed

2. Under 2 mgd safe yield, unless being considered for a diversion

3. Under 4 mgd safe yield, if relocation of transmission lines or pipelines is necessary

4. If relocation of 4 lane highways or railroads are required.

The following table lists the sites eliminated by Connecticut from further consideration.

DAMS	TOWN	DIVERSIONS
Limekiln Brook	Bethel	
Clatter Brook	Bridgewater	
Valley Brook	Cornwall	
	Danbury	Corner Pond
	Litchfield	W. Br. Bantam River
	New Milford	E. Aspetuck River
Pond Brook	Newtown	
Spaulding Brook	Norfolk	
Pequabuck River	Plymouth	
Carse Brook	Sharon	
Mad River	Winchester	
Short Woods Brook	New Fairfield	
Pootatuck River	Newtown	
Mountain Brook	Goshen	
	Goshen	Hall Meadow Brook
	Monroe	Copper Mill Brook
Deep Brook	Newtown	
Eight Mile Brook	Oxford	
Stream North of Beardsley Pond	Sharon	
Far Mill River	Shelton	
Weekeepeemee River	Woodbury	
Sprain Brook	Woodbury	
Nonewaug River	Woodbury	

Willow Brook	Cheshire	
Honeypot Brook	Cheshire	
Hop Brook	Middlebury	
Halfway River	Monroe	
Little River	Oxford	
Todd Hollow Brook	Plymouth	
	Shelton	Housatonic River
Pomperaug River	Southbury	

There are 7 surface water sites that were determined by the State as having the highest potential for future development. They are listed here and shown on Plate B-1.

1. Jakes Brook Dam and diversion by gravity channel to Reuben Hart Reservoir. It will increase the safe yield of Reuben Hart Reservoir by about 0.7 mgd.

2. Nickle Mine Brook Dam on the existing watershed of the Allen Dam in Torrington. The dam would increase the safe yield of the existing watershed by about 1.3 mgd.

3. Bantam River Dam located 0.4 miles north of Litchfield Borough boundry. The dam will provide a safe yield of about 6.4 mgd.

4. East Branch Leadmine Brook at Cooks Dam - Increase the capacity of the existing Cooks Dam to produce a safe yield of about 4.6 mgd.

5. Upper Shepaug Reservoir - Increase the capacity of the existing Shepaug Dam by about 15 mgd.

6. Leadmine Brook Diversion to Plymouth Reservoir for Bristol system. Estimated safe yield of diversion is 2.3 mgd.

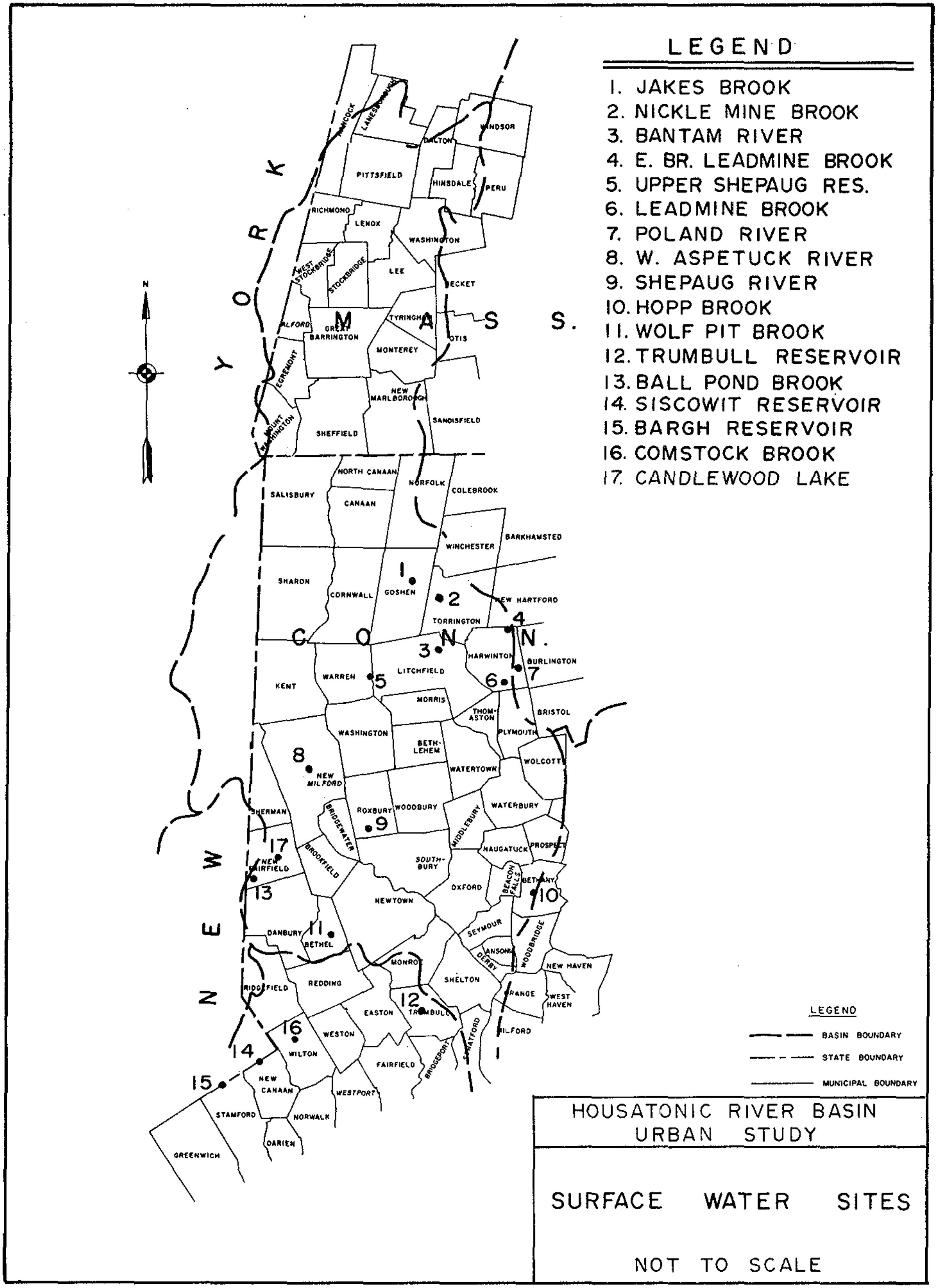
7. Poland River Diversion to existing Bristol Reservoir 7. Increases the existing safe yield by 1.0 mgd.

8. West Aspetuck River Dam could provide a safe yield of 17.9 mgd. It could also be used to divert water to the Southwestern Connecticut area similar to the Shepaug Diversion proposal.

9. Shepaug River Diversion has an estimated safe yield of 25 mgd. Reservoirs in Greenwich, Stamford, and Danbury could be used to store the diverted water.

10. Hopp Brook Dam to replace the existing diversion. Estimated safe yield is 2.0 mgd.

11. Wolf Pit Brook Dam in Bethel could provide an additional 1.1 mgd safe yield.


LEGEND
1. JAKES BROOK
2. NICKLE MINE BROOK
3. BANTAM RIVER
4. E. BR. LEADMINE BROOK
5. UPPER SHEPAUG RES.
6. LEADMINE BROOK
7. POLAND RIVER
8. W. ASPETUCK RIVER
9. SHEPAUG RIVER
10. HOPP BROOK
11. WOLF PIT BROOK
12. TRUMBULL RESERVOIR
13. BALL POND BROOK
14. SISCOWIT RESERVOIR
15. BARGH RESERVOIR
16. COMSTOCK BROOK
17. CANDLEWOOD LAKE
NEW YORK
MASS.
CONN.
N
PITTSFIELD
DALTON
WINDSOR
HINSDALE
PERU
RICHMOND
LENOX
WASHINGTON
WEST STOCKBRIDGE
STOCKBRIDGE
LEE
BECKET
ALFORD
GREAT BARRINGTON
TYRINGHAM
MONTEREY
OTIS
EGREMONT
NEW MARLBOROUGH
SANDISFIELD
MOUNT WASHINGTON
SHEFFIELD
NORTH CANAAN
NORFOLK
COLEBROOK
SALISBURY
CANAAN
WINCHESTER
BARKHAMSTED
SHARON
CORNWALL
GOSHEN
NEW HARTFORD
TORRINGTON
HARWINTON
BURLINGTON
LITCHFIELD
KENT
WARREN
MORRIS
BRISTOL
THOMASTON
PLYMOUTH
WASHINGTON
BETHLEHEM
WATERTOWN
WOLCOTT
NEW MILFORD
ROXBURY
WOODBURY
WATERBURY
SHERMAN
BRIDGEWATER
MIDDLEBURY
NAUGATUCK
PROSPECT
BROOKFIELD
SOUTHBURY
NEW FAIRFIELD
BEACON FALLS
BETHANY
OXFORD
NEWTOWN
SEYMOUR
DANBURY
BETHEL
ANSONIA
DERBY
WOODBRIDGE
MONROE
NEW HAVEN
SHELTON
RIDGEFIELD
REDDING
ORANGE
WEST HAVEN
EASTON
TRUMBULL
STRATFORD
MILFORD
WESTON
WILTON
FAIRFIELD
BRIDGEPORT
NEW CANAAN
WESTPORT
STAMFORD
NORWALK
DARIEN
GREENWICH
LEGEND
BASIN BOUNDARY
STATE BOUNDARY
MUNICIPAL BOUNDARY
HOUSATONIC RIVER BASIN
URBAN STUDY
SURFACE WATER SITES
NOT TO SCALE

12. Poquonock River (Trumbull Reservoir) in Trumbull could provide a safe yield of 7.0 mgd to Bridgeport Hydraulic Company.

13. Ball Pond Brook Diversion to Margerie Reservoir in Danbury could increase the safe yield of the system by 3.9 mgd.

14. Raising the Siscowit Reservoir could increase the safe yield of the Stamford system by about 2.0 mgd.

15. Raising the Mianus Reservoir in Stamford could increase the safe yield of the Greenwich System by 3.0 mgd.

16. Comstock Brook Dam in place of the existing diversion could increase the safe yield of the Norwalk 2nd Taxing District system by about 1.1 mgd.

17. Candlewood Lake due to its size could be a significant source for water supply.

Of the 17 sites listed, eight were eliminated because they are too far from the need areas. The transmission costs to transport the water to the demand centers is excessive and causes these sources to be economically infeasible. The sites eliminated are:

1. Jakes Brook Dam

2. Nickle Mine Brook Dam

3. Bantam River Dam

4. East Branch Leadmine Brook Dam

5. Upper Shepaug Reservoir

6. Leadmine Brook Diversion

7. Poland River Diversion

8. Hopp Brook Dam

Descriptions of the various water supply sources considered for further development are presented in the following paragraphs.

A 1973 feasibility report by Flaherty-Giavara Associates recommends a two phase project to pump water from Ball Pond Brook in New Fairfield to Margerie Reservoir which supplies the Danbury Water Company. The first phase would include a 24 inch transmission main into Margerie and the second phase an additional 20 inch main. The Margerie Lake Reservoir Dam would have to be increased by 8 feet to store the added capacity of the second phase. The safe yield would be increased by 1.9 mgd in the first phase and 1.8 mgd for the second phase. The total cost to construct both phases of this project in 1980 dollars is $4.3 million. The estimated cost does not include land acquisitions or relocations. The added cost to acquire the needed 80 acres and to relocate two homes is estimated at $1 million. Therefore, the total cost for the Ball Pond Diversion is $5.3 million.

The Wolf Pit Brook proposal includes a 40 ft. high dam located on Wolf Pit Brook in Bethel just east of Route 58. The reservoir would impound 240 million gallons of water and provide a safe yield of 1.1 mgd. The dam would be about 1800 feet in length with a spillway elevation of 460. The estimated cost to develop this proposal is $4.8 million.

The source was dropped from further consideration, however, when it was discovered that the reservoir site has undergone intense development in the past few years. The social impact and increased development cost preclude it from be used as a water supply site.

The Poquonock River in Trumbull was identified by the Corps of Engineers as a site for a multi-purpose dam for flood control and water supply. The impoundment would provide Bridgeport Hydraulic with a 7 mgd safe yield. It was found to be a justified project in 1974. It would have been cost shared between the State and the Corps. It is still an authorized project and could be built provided the benefit to cost ratio (b/c) does not dip below one.

The Siscowit Reservoir is located in Pound Ridge, New York along the Rippowam River. It is presently used as a source of supply for the Stamford Water Company and has a safe yield of 0.7 mgd. Further development of this site includes constructing a new dam 25 feet high, which will increase the safe yield to 2.7 mgd. Formulation of this plan indicated a total project cost of over $9 million.

The Mianus Reservoir (Bargh) is a water supply storage reservoir, located in Stamford, providing potable water to residents of Greenwich. The existing dam has a storage capacity of 7515 acre feet for a safe yield of 10.2 mgd. A proposal to raise the dam 20 feet to provide a storage of 12,745 acre feet was investigated. The total cost of the plan would be about $8 million, but would provide an additional 3 mgd of safe yield.

Comstock Brook was investigated as a site for a dam to provide a safe yield of 1.1 mgd for the Norwalk 2nd Taxing District. A portion of the brook is presently diverted into the South Norwalk Reservoir. Preliminary estimates indicate it will cost about $3 million to develop this source.

The Mianus Pond is located at the base of the Mianus River and has a total storage of 275 million gallons. There is an existing facility, at the pond, owned by Conrail which is scheduled to close down in the near future. The pond could be utilized by Greenwich, which would increase the system's safe yield by almost 2.5 mgd.

The East Branch Mianus River develops a significant amount of runoff, that can be diverted into the Bargh Reservoir. This plan will increase the safe yield of the Greenwich System by about 1 mgd. This proposal was carried forward into the development of alternative plans.

Candlewood Lake is a large impoundment with a storage capacity of 172,000 acre-feet. The lake is presently used to generate electricity and for recreation. The lake was evaluated for use as a water supply source for Danbury and also for the southwestern coastal area.

Importation

Studies were conducted to determine the feasibility of importing water to the southwestern need area from within the Housatonic Basin. Two sources of water were investigated for major diversions, the Shepaug River and the West Aspetuck River. The Shepaug River is a major river with a 131 square mile watershed, capable of supplying enough water to meet all of the projected 2030 demands of the southwestern area. The West Aspetuck is smaller with a watershed area of only 26 square miles, but is capable of meeting many of the short-term demands of the area

The Shepaug River is the largest potential source of water investigated for future use. Three diversion schemes were investigated (1) divert water to Danbury, Greenwich and Stamford, (2) divert water to Greenwich and Stamford and (3) divert water to Bridgeport Hydraulic.

The first proposal is a 2 stage plan to meet the 2030 demands of Danbury, Stamford and Greenwich. The river flow would be diverted during the December to May high flow period into existing reservoirs, namely: Margerie, Trinity and Bargh Reservoirs. The safe yield of the Danbury system would be increased by 4 mgd, the Stamford System by 4.5 mgd and the Greenwich System by 2.5 mgd.

The second proposal is similar to the first except Danbury would not receive any water. In this proposal 11 mgd is transported to supply the 2030 demands of Greenwich, Stamford, Norwalk 1st and Norwalk 2nd.

The third proposal is to divert the Shepaug River into the existing Bridgeport Hydraulic reservoir system. This extra source of supply will allow Bridgeport Hydraulic to expand its service into the southwestern area to help meet their 2030 demands. This proposal would increase the safe yield of the Bridgeport Hydraulic system by 10 mgd.

The West Aspetuck River was originally identified as a possible impoundment site for a reservoir yielding 17.9 mgd, Due to the extremely high cost ($65 million) and the adverse social impact (relocating 60 homes) the reservoir plan was dropped from further consideration. It was investigated for a possible diversion of 5 mgd to the Danbury and southwestern need areas. This plan is equal in cost to the first stage of the Shepaug Diversion proposal.

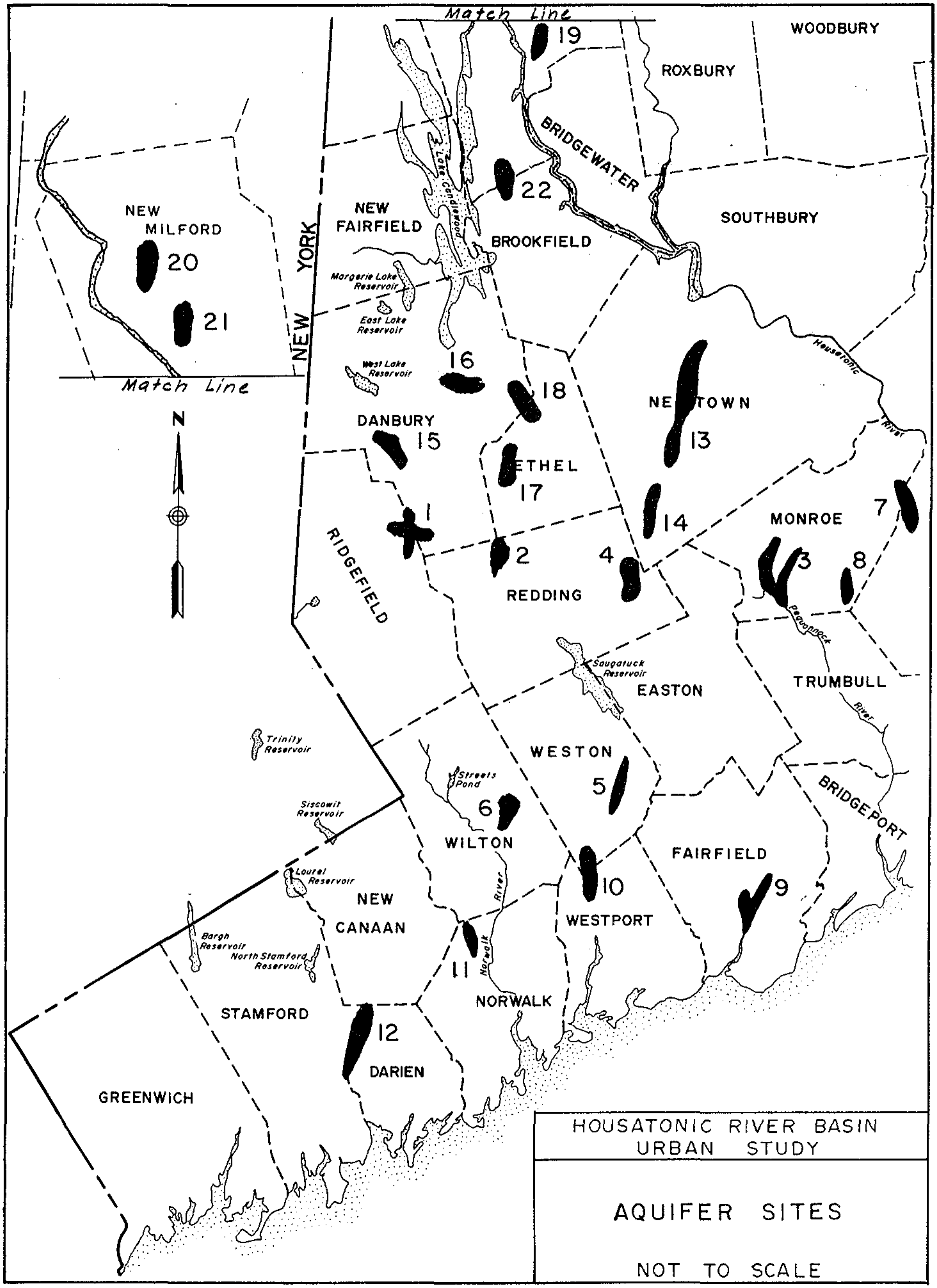
Groundwater Resources. All the potential stratified drift aquifer sites in Connecticut are delineated on the DEP map "Groundwater availability in Connecticut" 1978 by Daniel Meade. The aquifer sites within a reasonable distance from the need areas were identified using this map. These sites are listed on the following Table B-3 along with the major source of information about them. Plate B-2 shows the location of each aquifer investigated.

TABLE B-3
POTENTIAL AQUIFER SITES INVESTIGATED

Aquifer	Town	Source
1. Sugar Hollow	Danbury	Aquifer Assessment
2. Upper Saugatuck	Redding	"
3. Upper Pequonock	Monroe	"
4. Aspetuck Valley	Redding	"
5. Lyons Plain	Weston	"
6. Cannondale	Wilton	"
7. Means Brook	Shelton	"
8. Farmill River	Monroe	"
9. Lower Mill River	Fairfield	USGS Bulletin #17
10. Lower Saugatuck	Westport	"
11. Deering Pond	Norwalk	"
12. Springdale (Noroton River)	Stamford	"
13. Pootatuck River	Newtown	USGS Model
14. Upper Aspetuck	Newtown	HVCEO
15. Lake Kenosia	Danbury	"
16. Still River, West	Danbury	"
17. Sympaug Brook	Bethel	"
18. East Swamp	Danbury	"
19. Pickett District	New Milford	"
20. East Aspetuck	New Milford	"
21. New Milford Center	New Milford	"
22. Brookfield, North	Brookfield	"

Preliminary estimates of the cost to transport the water from the aquifers to the need areas indicated some of the sites were not economically feasible to develop. In most cases these sites had a low safe yield and were over 5 miles from the need areas. Those eliminated from further study for this reason include:

7) Means Brook
8) Farmill River
9) Lower Mill River
19) Pickett District
20) E. Aspetuck
21) New Milford Center
22) Brookfield, North


Match Line
Match Line
WOODBURY
ROXBURY
BRIDGEWATER
SOUTHBURY
NEW MILFORD
NEW YORK
NEW FAIRFIELD
Lake Candlewood
BROOKFIELD
Margerie Lake Reservoir
East Lake Reservoir
West Lake Reservoir
DANBURY
NEWTOWN
Housatonic River
BETHEL
MONROE
RIDGEFIELD
REDDING
Pequonnock River
Saugatuck Reservoir
EASTON
TRUMBULL
Trinity Reservoir
WESTON
Streets Pond
BRIDGEPORT
Siscowit Reservoir
WILTON
FAIRFIELD
Laurel Reservoir
NEW CANAAN
Norwalk River
WESTPORT
Bargh Reservoir
North Stamford Reservoir
STAMFORD
NORWALK
DARIEN
GREENWICH
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HOUSATONIC RIVER BASIN
URBAN STUDY
AQUIFER SITES
NOT TO SCALE

PLATE B-2

The Lyons Plain, Lower Saugatuck, Deering Pond and East Swamp aquifers, numbers 5, 10, 11 and 18 respectively, are presently developed to capacity and there is no excess safe yield available for future use. Therefore, these four aquifers have been eliminated from further study.

Two aquifers, the Springdale and the Sympaug Brook, were found to be extremely urbanized and their existing water supply wells were closed due to contamination. As a result of this they were not considered as future water supply sources.

The Sugar Hollow aquifer is located in the southwestern corner of Danbury on the upper reaches of the Saugatuck River. Preliminary indications show that the aquifer has a potential to yield approximatley 500,000 gallons per day. It was investigated as a possible future source for use by Danbury, Bethel or Ridgefield.

The Cannondale aquifer is located in the central portion of the town of Wilton along the Norwalk River. The aquifer is estimated to have a 2.5 million gallons per day potential safe yield. It is presently being studied by the Bridgeport Hydraulic Company, the Norwalk 2nd Water Department and the town of Wilton as a future water supply source. It is a very good potential source for future supply.

The Pootatuck Valley aquifer is located in the east-central portion of Newtown. It is estimated to have a potential safe yield of 4 million gallons per day. Because of its location it is only being developed as a source for the town of Newtown.

The Lake Kenosia aquifer is located in Danbury just northeast of Lake Kenosia. The Danbury Water Department presently uses the aquifer for water supply, but the aquifer has the potential to yield more than is being utilized. It is being investigated as a future source for Danbury.

The Still River, west aquifer is in the central portion of Danbury. It is the location of the Osborne Street well, which was used during the 1960's drought. It is a potential source to be reactivated for future use.

Surface Water Resources. The surface water sites were initially identified in Massachusetts by the Soil Conservation Service in a study entitled, "A Study of Potential Reservoir Sites - Housatonic Study Area Massachusetts", dated June, 1969. The report identified potential reservoir sites within the Housatonic River study area. The purpose of the report is to assist State agencies, towns, regional planning groups and other interested persons, in developing project plans for conservation, use, development and utilization of the Massachusetts water resources.

The report presents data on 182 existing and potential reservoir sites in the Housatonic River drainage area, Berkshire County, Massachusetts. The information presented considers water resource potentials for water supply, flood prevention, recreation, low flow augmentation, fish and wildlife, and other beneficial uses.

The criteria used to identify potential reservoir sites were physical characteristics necessary to impound water; sufficient site drainage area to sustain reservoir storage; and little or no man-made or natural obstructions. Additional criteria used as a guide in site selection are as follows:

1. Drainage area - larger than 1/2 sq. mile, but not greater than 50 sq. miles.

2. Ratio of drainage area to potential pool surface area not less than 10 to 1.

3. Minimum beneficial pool depth 7 ft. at dam.

4. Minimum beneficial pool area - 10 acres.

5. Minimum beneficial pool capacity - 10 acre feet.

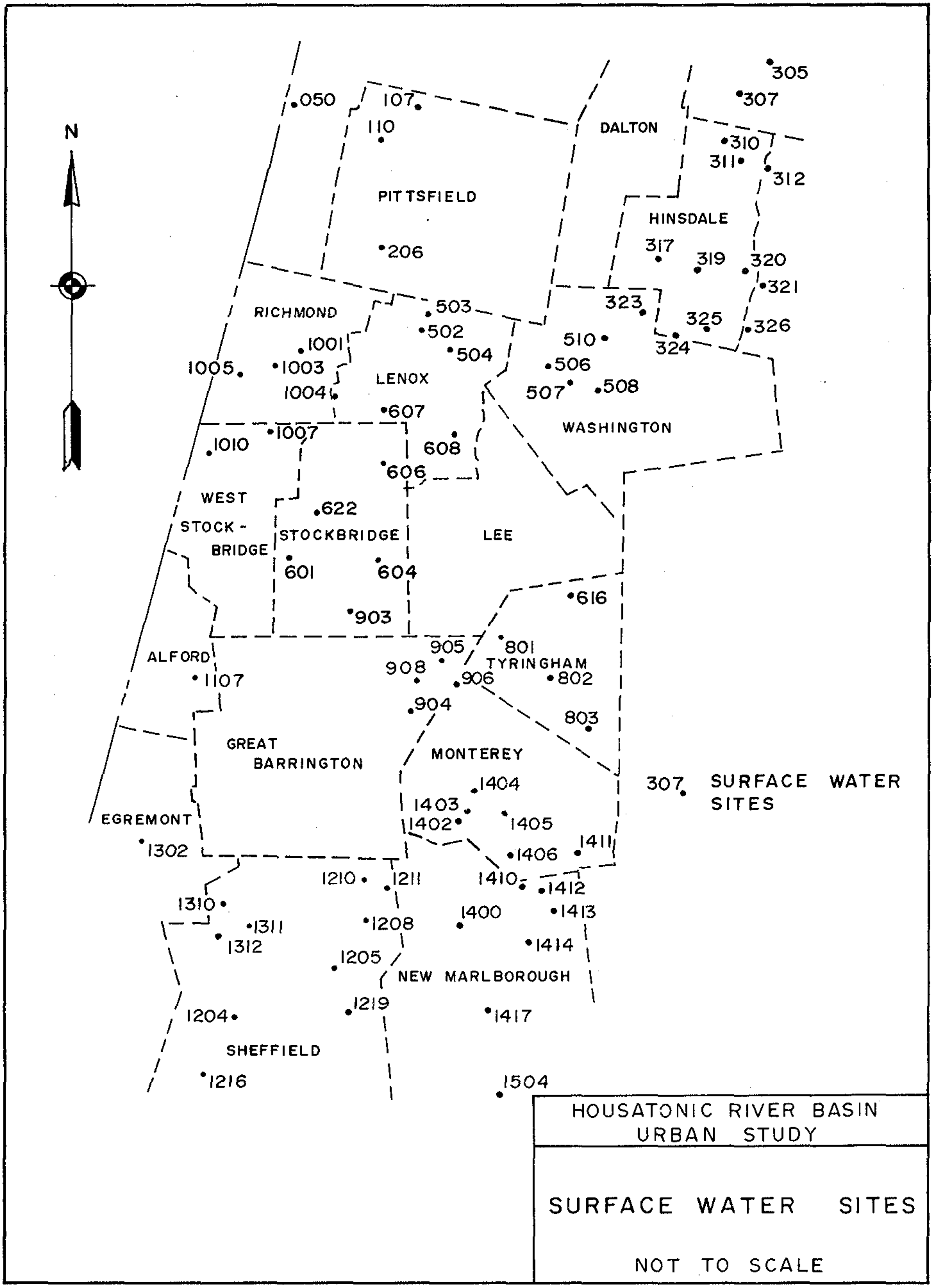
6. Pool area - no extensive residential or commercial development.

The study made no attempt in the inventories to evaluate the potential of the sites for specific purposes such as water supply, recreation, etc. Unfortunately, many of the sites which first appeared promising failed to meet the more stringent criteria required for a good water supply reservoir. Among the more common problems were poor geologic conditions, recent development of the pool area and extremely high cost.

The potential reservoir sites were reevaluated by the SCS for the 1977 report "Water and Related Land Resources of the Berkshire Region". The 74 reservoir sites presented in Appendix B, of that report, represent the prime possibilities for permanent water storage sites in the Berkshire Region. Topography, geology, and affected man-made facilities appear to be favorable.

The 74 potential reservoir sites are identified in the following table and shown on the map on Plate B-3.

Site Number	Town	Site Number	Town
101	Lanesborough	324	Hinsdale
107	Pittsfield	325	Hinsdale
110	Pittsfield	326	Peru
206	Pittsfield	502	Lenox
301	Windsor	503	Lenox
303	Windsor	504	Lenox
305	Windsor	506	Washington



HOUSATONIC RIVER BASIN URBAN STUDY

SURFACE WATER SITES

NOT TO SCALE

PLATE B - 3

Site Number	Town	Site Number	Town
307	Windsor	507	"
310	Hinsdale	508	"
311	Hinsdale	510	"
312	Peru	601	Stockbridge
317	Hinsdale	604	"
319	Hinsdale	606	"
320	Hinsdale	607	Lenox
321	Peru	608	Lenox
323	Washington	616	Tyringham
622	Stockbridge	1502	New Marlborough
801	Tyringham	1504	" "
802	"	1505	" "
803	"		
903	Stockbridge		
904	Great Barrington		
905	"		
906	"		
908	"		
1001	Richmond		
1003	"		
1004	Lenox		
1005	Richmond		
1007	West Stockbridge		
1010	" "		
1107	Alford		
1204	Sheffield		
1205	"		
1208	"		
1210	"		
1211	"		
1216	"		
1219	"		
1302	Egremont		
1310	Sheffield		
1311	"		
1312	"		
1402	Monterey		
1403	"		
1404	"		
1405	"		
1406	"		
1408	New Marlborough		
1410	" "		
1411	Monterey		
1412	New Marlborough		
1413	" "		
1414	" "		
1417	" "		

The initial screening, as the result of preliminary investigations of each site including; location in relation to the demand centers, size and potential safe yield, cost to develop and transport the water and the major environmental impacts, resulted in eliminating 49 potential sites from further study. The remaining 25 sites were investigated in greater detail, both economically and environmentally.

The U.S. Fish and Wildlife Service (FWS) has developed a methodology called the Habitat Evaluation Procedures (HEP). The purpose of HEP is to provide a uniform and quantifiable habitat assessment of project impacts on fish and wildlife resources. The FWS used the Habitat Evaluation Procedures to rank the 25 potential reservoir sites. The following table gives the results of the HEP evaluation. A March 1981 "Habitat Evaluation Procedures" report explaining the procedure and results of the studies in the Housatonic Basin are available upon request.

HEP RANKING OF POTENTIAL RESERVOIR SITES

Site #	Rank	Site #	Rank
1007	1	506	16
305	2	206	17
307	3	601	18
1010	4	321	19
1107	5	1310	20
310	6	904	21
1003	7	508	22
320	8	507	23
905	9	1302	24
908	10	604	25
622	11		
1005	12		
326	13		
323	14		
110	15		

There are 13 potential sites that still appear feasible and were carried forward into alternative development. Those sites include the following:

RECOMMENDED FOR FURTHER STUDY

Site	River	Town
305	Windsor Brook	Windsor
307	Windsor Brook	Windsor
310	Cady Brook	Hinsdale
320	Tracy Brook	Hinsdale
321	Tracy Brook	Peru
506	Rearing Brook	Washington

601	Mohawk Brook	Stockbridge
604	Kampoosa Brook	Stockbridge
622	Lake Averic	Stockbridge
1007	Cone Brook	W. Stockbridge
1010	Baldwin Brook	W. Stockbridge
1107	Alford Brook	Alford
1302	Unnamed Brook	Egremont

Groundwater Resources. The potential aquifer sites for the Massachusetts portion of the basin were identified in the report, "Water and Related Land Resources of the Berkshire Region". The aquifers have been identified and evaluated to varying levels by the USGS, the State and private consultants (see Appendix C). Of the 12 listed on Table B-4 and shown on Plate B-4, only Town Brook was eliminated because it is presently used for water supply purposes. It is the only source of supply for the Town of Lanesborough.

The Loom Brook aquifer located in the Town of Monterey was eliminated due to the location of the nearest need area. It is not engineeringly feasible or economically justified to transport the water the distances required.

The Dalton aquifer is located in the west central part of Dalton, adjacent to the East Branch of the Housatonic River. The aquifer is presently being used by industrial firms in the area but has an estimated unused potential of 1.2 mgd. This aquifer is being investigated as a possible addition to the Pittsfield system.

Table B-4
POTENTIAL AQUIFER SITES IN MASSACHUSETTS

Aquifer Name	Town
Dalton (DA)	Dalton
Daniels Brook (DB)	Pittsfield
Glendale (GD)	Stockbridge
Greenwater Brook (GB)	Lee
Lake Buel (L BU)	Great Barrington
Lenoxdale (LX)	Lee
Loom Brook (LB)	Monterey
Secum Brook (SB)	Lanesborough
South Pittsfield (SP)	Pittsfield
Town Brook (TB)	Lanesborough
Van Deusenville (VD)	Great Barrington
Vincent Farm (VP)	Pittsfield
Brattle Brook (BB)	Pittsfield

The Daniels Brook aquifer is located just north of Lake Onota on the Pittsfield - Lanesborough town line. This aquifer has been estimated to have a total potential safe yield capability of only 0.5 mgd. It will be investigated for possible use by Pittsfield.

The Glendale aquifer is located along the Housatonic River near the village of Glendale in the southern portion of Stockbridge. It is estimated that this aquifer has a potential safe yield of 0.8 mgd. It is being studied as a possible future source of supply for Great Barrington, Stockbridge or West Stockbridge.

The Greenwater Brook and Lenoxdale aquifers have been studied in the Washington Mountain Brook project by SCS for possible use by Lee or Lenox.

The Lake Buel aquifer is located on the west side of Lake Buel and overlaps the boundary between Great Barrington and Monterey. It is estimated that the aquifer could provide a safe yield of 0.9 mgd. The aquifer is being studied as a possible source for Great Barrington or Egremont.

The Secum Brook aquifer is located just northwest of Pontoosuc Lake in the town of Lanesborough. Preliminary studies indicate that the aquifer could provide a 1 mgd safe yield. It is being investigated as a possible source for Pittsfield.

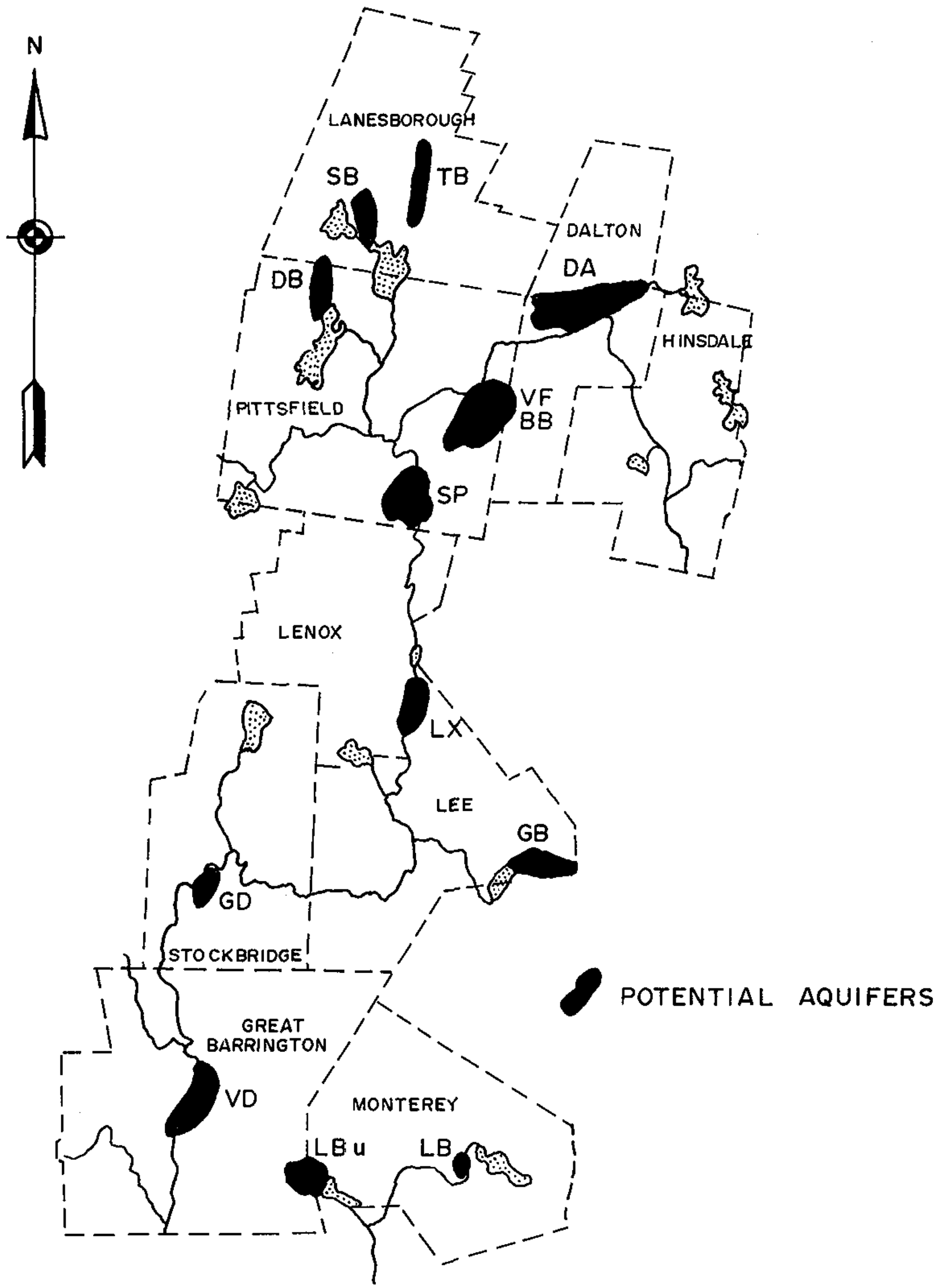
The South Pittsfield aquifer is located on the west bank of the Housatonic River in the southern portion of Pittsfield. The aquifer has a high potential yield of 3.5 mgd and is being studied as a possible future source for Pittsfield.

The Van Deusenville aquifer is located immediately adjacent to the Housatonic River in the northern part of the town of Great Barrington. This aquifer is estimated to have a potential safe yield of 2.5 mgd. It is being studied for possible use by Great Barrington, Stockbridge, W. Stockbridge and Egremont.

The Vincent Farm - Brattle Brook aquifer is located in the eastern portion of Pittsfield, and is the largest in the area. It is estimated to have a potential safe yield of 5.4 mgd. This aquifer could be a significant additon to the Pittsfield system.

Intermediate Screening

The results of the intermediate screening and evaluation process to determine the most applicable water supply management measures for the study area are shown in Table B-5 and B-6. During this phase of the plan formulation process, described in the preceding paragraphs, attempts were made to assess each management measure in relation to plan formulation alternatives for satisfying the water supply needs of the study area. Only those measures that made positive contributions towards fulfillment of the study's planning objectives and which offered the most economically and environmentally acceptable solutions to the water supply needs identified were retained for development of intermediate plans.



HOUSATONIC RIVER BASIN
URBAN STUDY

POTENTIAL AQUIFERS

NOT TO SCALE

PLATE B-4

Investigations revealed that of the potential measures passing the initial screening phase, the most applicable resource management measures for development of intermediate plans consist of 1) water conservation 2) surface water resources and 3) groundwater resources.

Table B-5
Intermediate Screening of Management Measures - Ct.

Applicable Measure	Further Evaluation Warranted	Evaluation Criteria Not Met
Nonstructural		
Water Conservation	Yes	
Structural		
Surface Water		
1) Jakes Brook Dam	No	2
2) Nickle Mine Brook Dam	No	2
3) Bantam River Dam	No	2
4) E. Branch Leadmine Brook Dam	No	2
5) Upper Shepaug Reservoir	No	2
6) Leadmine Brook Diversion	No	2
7) Poland River Diversion	No	2
8) W. Aspetuck Diversion	Yes	
9) Shepaug River Diversion	Yes	
10) Hopp Brook Dam	No	2
11) Wolf Pit Brook Dam	No	2,3
12) Pequonock River Dam	Yes	
13) Ball Pond Diversion	Yes	
14) Siscowit Reservoir Raising	Yes	
15) Bargh Reservoir Raising	Yes	
16) Comstock Brook Dam	Yes	
17) E. Branch Mianus Diversion	Yes	
18) Mianus Pond	Yes	
Interconnections	Yes	
Groundwater	Yes	

Evaluation Criteria

1. Technical Feasibility
2. Economic Feasibility
3. Social Feasibility
4. Environmental Feasibility

Table B-6
Intermediate Screening of Management Measures - MA

Applicable Measure		Further Evaluation Warranted	Evaluation Criteria Not Met
Nonstructural			
Water Conservation		Yes	
Structural			
Surface Water			
Reservoir Number	110	No	2, 4
	206	No	2, 4
	305	Yes	
	307	Yes	
	310	Yes	
	320	Yes	
	321	Yes	
	323	No	2, 4
	326	No	2, 4
	506	Yes	
	507	No	2, 4
	508	No	2, 4
	601	Yes	
	604	Yes	
	622	Yes	
	904	No	1, 2, 4
	905	No	1, 2,
	908	No	1, 2,
	1003	No	2
	1005	No	2
	1007	Yes	
	1010	Yes	
	1107	Yes	
	1302	Yes	
	1210	No	
Groundwater		Yes	

Evaluation Criteria

1. Technical Feasibility
2. Economic "
3. Social "
4. Environmental "

DEVELOPMENT OF INTERMEDIATE ALTERNATIVES

General

As a result of reconnaissance and preliminary type estimates, preliminary screening, and analysis of applicable management measures, an array of alternative plans that would address the planning objectives of the Housatonic Urban Study were considered utilizing either one or a combination of the applicable measures for water supply management described in the preceding sections. Alternatives were developed that addressed the water supply needs of the study area incorporating both structural and nonstructural measures and focused on the water requirements projected for both short-term (2000) and long-term (2030) planning periods.

A "home rule" approach has long governed development of water supply sources in New England. Because of this traditional approach it was felt that the formulation and evaluation of plans would be more responsive to local officials' and States' needs if conducted on a community by community or small regional system (five communities or less) basis. Since in some cases a community may have had more than one alternative which after screening was considered feasible, all feasible options for the communities have been presented.

The following discussion of alternatives initially discusses the Shepaug River and West Aspetuck River diversions, because these two are regional solutions, then continues into alternative plans for each community.

CONNECTICUT

Shepaug Diversion

The Shepaug River Diversion is one of the primary regional water supply alternatives for the Housatonic Basin and Southwestern demand centers. There is much concern about its feasibility as a water supply source, associated impacts and total cost.

All costs presented in this report are preliminary and are used only for comparison of the water supply alternatives being considered.

Background of the Shepaug Diversion. The 1974 Connecticut Plan of Conservation and Development is the official state policy document on land and water resource matters, and proposes that the Shepaug Valley (see Plate B-5) be permanently committed to open space land uses, and that the Shepaug's flow be diverted for water supply purposes at a point just north of where it joins the Housatonic River in Lake Lillinonah.

In 1976, a report was prepared for the Housatonic Valley Council of Elected Officials advancing the concept of a Shepaug diversion at the same location for water supply purposes. The report estimated that such a project would deliver a safe yield of approximately 30 million gallons daily at a cost of $30 million.

Transmission Facilities. The largest cost associated with the Shepaug Diversion is the transmission main. The cost has been estimated for the transmission main from the Shepaug River to Margerie Reservoir, Trinity Reservoir and the Bargh Reservoir.

The transmission main would be over 38 miles long and would cost \$36,100,000. The two pump stations will cost about \$6,100,000.

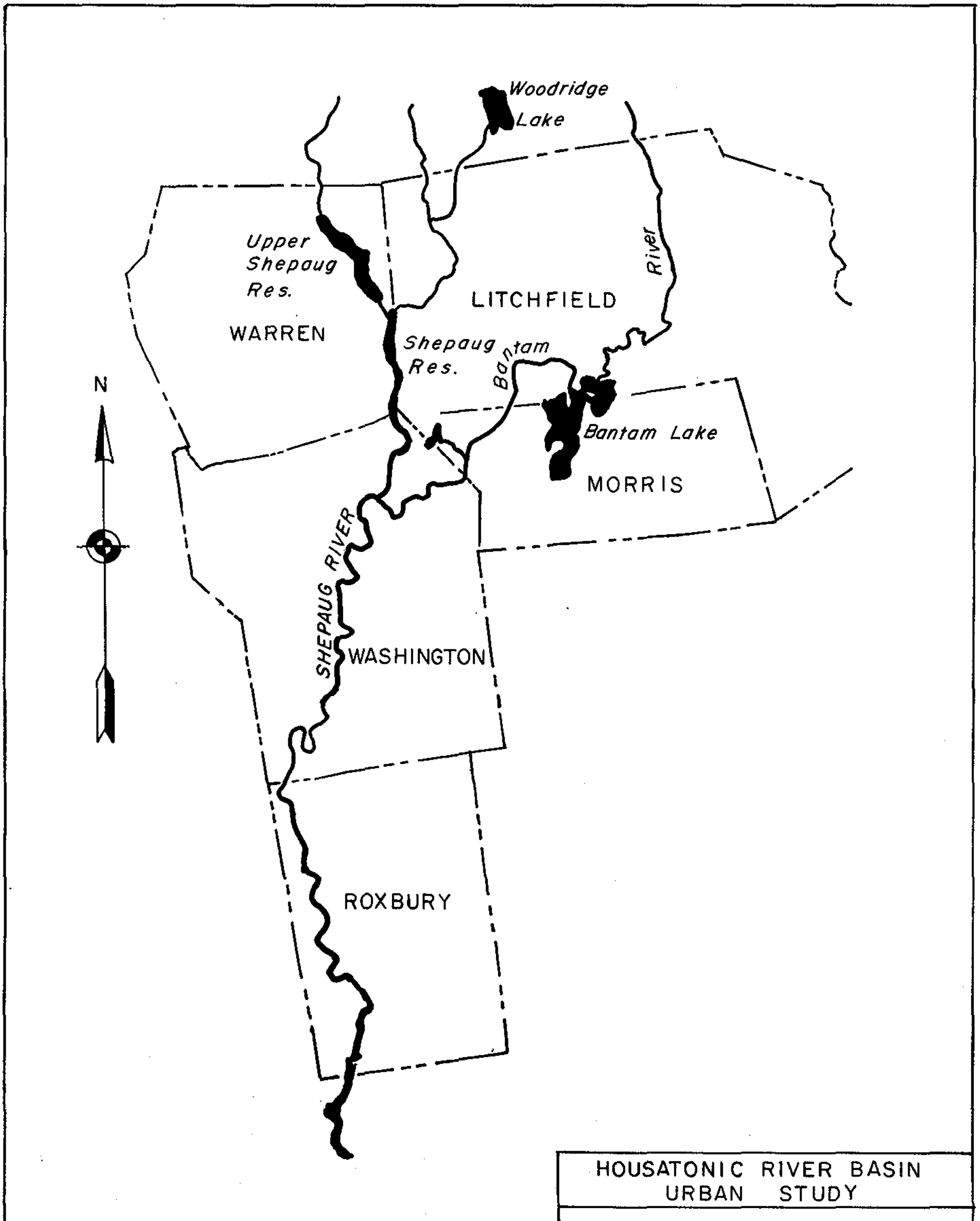
Diversion Structure. There are many different types of diversion structures that could be built to handle this quantity of water. If the inlet is located at the proper location along the river, a sill across the river to keep out Housatonic River water would not be required. In any case a diversion structure of this size would not cost more than about \$150,000.

Shepaug Alternatives. Each of the existing water supply reservoirs in the need areas were investigated to determine if they had capacity to store diverted water from the Shepaug River. Those proving to have adequate holding capacity are the Trinity Reservoir in the Stamford System, the Bargh Reservoir in the Greenwich System and the Margerie Reservoir and West Lake in the Danbury System. The following alternative plans for the Shepang River utilize these four reservoirs.

The first plan includes diverting 11 mgd from the Shepaug River, in 1990. A pump station would be required to send the water through the 54 inch pipe to the Danbury Area, where 4 mgd would be deposited. Another pump station would send the remaining 7 mgd through a 42 inch pipeline to the Stamford and Greenwich area. Greenwich would receive 2.5 mgd and Stamford the remaining 4.5 mgd. The total cost of this alterntive is approximately \$42 million which yields an average annual cost of \$4.4 million.

The second plan investigated also diverts 11 mgd from the Shepaug River. The difference is that it is a two phase plan. The Phase 1 in 1990 would divert 7 mgd from the Shepaug River through a 42 inch pipeline. After dropping off 2.5 mgd in Danbury a 36 inch pipeline continues into the Stamford-Greenwich area supplying 3 mgd to Stamford and 1.5 mgd to Greenwich. The total cost of this phase would be \$29.5 million. The average annual cost of this plan would be about \$2.9 million.

Phase 2 would be constructed in the year 2010 or when demand warrants it. The capacity of the Phase 1 pump stations would be increased to handle the additonal flow. New transmission mains would be laid parallel to the old ones. This phase would require a 36 inch pipeline to carry the 4 mgd, and a 30 inch pipeline after dropping off 1.5 mgd in Danbury. The cost of Phase 2 would be approximately \$24.6 million, which yields an average annual cost of \$470,000. The average annual cost of both phases is only \$3.7 million as compared to the \$4.4 million cost of alternative one.



HOUSATONIC RIVER BASIN URBAN STUDY

SHEPAUG RIVER BASIN

NOT TO SCALE

The third alternative considered the option of using the Shepaug River water just for the southwestern area and eliminating use by Danbury. This alternative was also evaluated in two phases. Phase 1 in 1990, includes diverting 6 mgd via a 42 inch pipeline to the southwestern area. 1.5 mgd will be going to the Greenwich System and 4.5 mgd to the Stamford System. Stamford will not require this quantity of water in the near future. Interconnections should be made with New Canaan and Norwalk thru Darien. This would enable Stamford to supply Shepaug water to these communities as their demand warrants. The total cost of Phase 1 excluding any interconnections is about $31.7 million with an average annual cost of $2.4 million.

Phase 2 of this alternative would include increasing the capacity of the two Phase 1 pump stations and laying parallel pipelines along the same route in the year 2010. Phase 2 would divert an additional 5 mgd of which 3.5 mgd would be stored in the Stamford Water Company's Trinity Reservoir. This phase of the plan would cost approximately $26.2 million which would have an average annual cost of $400,000. The total average annual cost of both phases is $2.85 million. A comparison of the three alternatives is shown in the following table.

Shepaug Diversion Alternatives*

	Danbury	Stamford	Greenwich	Total
Alt, 1				
Safe Yield	4.0	4.5	2.5	11
Total Cost	$9.2	$19.85	$13.15	$41.2
Annual Cost	$1.05	$ 2.10	$ 1.25	$ 4.4
Alt. 2				
Phase 1				
Safe Yield	2.5	3.0	1.5	7
Total Cost	$5.65	$14.8	$9.05	$29.5
Annual Cost	$ .65	$ 1.45	$ .80	$ 2.9
Phase 2				
Safe Yield	1.5	1.5	1.0	4
Total Cost	$4.10	$10.75	$9.70	$24.55
Annual Cost	$ .085	$ .20	$ .17	$ 0.46
Alt. 3				
Phase 1				
Safe Yield		4.5	1.5	6
Total Cost		$22.55	$9.15	$31.7
Annual Cost		$ 1.80	$ .65	$ 2.45
Phase 2				
Safe Yield		3.5	1.5	5
Total Cost		$16.40	$9.85	$26.25
Annual Cost		$ .25	$ .15	$ 0.4

* All Safe Yields in mgd
All costs in $ millions

Shepaug River Impacts. When discussing the diversion of water from the Shepaug River, the segment of the river most affected would be that situated directly below the diversion. In this case, the Shepaug River flows from an elevation of 210 feet at the diversion until it levels off in Lake Lillinonah at 195 feet a distance of approximately 2000 feet. The lake then extends 3.7 miles downstream to make the entire impact area approximately 4 miles. Included within this short stretch is a series of small rapids which make up the lower end of Roxbury Falls. This is a very aesthetically pleasing area that may be adversely affected by a diversion of water above this point. A gaging station near the mouth of the Shepaug River in the Town of Roxbury, at which the most useful data on Shepaug's flow is gathered, indicates the mean annual discharge is 236 cubic feet per second (CFS). For comparative reference, research indicates that 375 CFS is needed for canoeing without dragging or portage. However, only under unusual circumstances does flow fail to exceed 33 cubic feet per second at any point in the stream, which is sufficient to protect aquatic life. A value of 165 CFS is considered necessary for enhancement of the stream's fishery resources.

There will be less water entering Lake Lillinonah because of the diversion but this should not have any impact on fisheries or wildlife in the area. The lake is not stocked with trout, however, the native species include large and smallmouth bass, yellow perch, white perch, yellow bullhead, brown bullhead, northernpike, common sunfish and bluegill. According to State officials, the area is not heavily used by local fishermen.

The decrease in water entering Lake Lillinonah is not anticipated to have any significant effect on the hydropower generating capabilities of the facility at the dam. The diversion will be made during the high flow season when Connecticut Power and Light Company is in the process of releasing excess water.

One of the special values found in the river corridor is the abundance of plantlife. Where flood plains are not cleared for cultivation they are thick with trees and shrubs in varying stage of maturity. Likewise, the valley walls are an almost unbroken carpet of green. Ferns grow from cracks and crevices in the frequent rock outcrops and the riverbanks and ravines that disappear into the hillsides support a heavy growth of plants such as trilliums, skunk cabbage, May apple and bloodroot.

The major regional forest vegetation is Central Hardwoods - Hemlock-White Pine. Characteristic dominant species include Red Oak, White Oak, Black Oak, Shagbark Hickory, Pignut and Bitternut Hickory. Black Birch, White Ash and several other oaks are frequent associates. White Pine and Hemlock are frequent and locally abundant to dominant.

The lower end of the Shepaug is also a great medium for rare plants to establish communities. According to a state botanist, specific species have recently been observed within the Shepaug River itself. Some rare plant species found in the area include the New England Grape, and Hairy Wood-Minet and Wiegand's Wild Rye.

The 26 mile segment of the Shepaug River upstream of the diversion site has been recommended for wild and scenic river designation. It is being studied for possible inclusion in the National Wild and Scenic Rivers Act. It does not appear as though the diversion would effect its designation as a Wild and Scenic River.

The streamflow for the 1960's drought, at the USGS gaging station in Roxbury, was reviewed. The minimum recorded flow for each month over the period from 1963-1968, which is the minimum flow period of record, is identified in the following table, in million gallons per day. The next column in the table lists the estimated average flow in the river, based on the over 40 years of record at the gaging station. The next two columns indicate the amount of water that must be diverted from the river and the resultant flow in the river in order to obtain 11 mgd safe yield. The last two columns show the effect on the river of a diversion capable of producing 25 mgd safe yield.

It appears that 25 mgd is the maximum safe yield that can be obtained from the Shepaug River. But, in order to provide a safe yield of 25 mgd the facilities would have to be designed to divert over 123 mgd, which is not very feasible due to the tremendous pumping costs that would be involved.

			Shepaug Division Alternatives		25 mgd Diversion	
Month	Worst Recorded Flow(mgd)	Estimated Average Flow(mgd)	Withdrawals	Remaining Flow(mgd)	Withdrawals	Remaining Flow(mgd)
O	6	8	0	6	0	6
N	8	27	0	8	0	8
D	36	120	19	17	19	17
J	39	130	22	17	22	17
F	116	385	36	80	99	17
M	140	465	36	104	123	17
A	112	375	36	76	95	17
M	60	200	35	25	43	17
J	19	65	2	17	2	17
J	10	33	0	10	0	10
A	5	17	0	5	0	5
S	5	17	0	5	0	5

The 17 mgd flow identified in the table is a minimum flow requirement assuming a 0.2 csm (cubic feet per second per square mile of drainage area).

One problem with implementation of a Shepaug Diversion is the fact that there are sewage discharges upstream that may have to be removed. This study did not estimate the cost or feasibility of removing those discharges.

West Aspetuck River Diversion

The lower portion of West Aspetuck River was originally identified as a potential site for a dam. But, because of intense development in the proposed reservoir area it was eliminated from further consideration as an impoundment. It was then studied as a diversion site. Preliminary investigations indicate a maximum safe yield of 4.7 mgd could be obtained. This diversion was evaluated for use in the future by Greenwich, Danbury and Stamford.

Two different alternative plans using the West Aspetuck River were investigated. The first assumed water would be diverted to the Danbury system, Stamford system and the Greenwich system. This plan would require installation of over 41 miles of transmission main ranging in size from 18 inches to 36 inches. The pipeline route would be similar to the Shepaug Diversion and is shown on plate B-6. The total cost for the pipeline, 2 pump stations and diversion structure is $23.9 million which yields an average annual cost of $2.35 million. The 4.7 mgd that would be diverted could be stored in the existing reservoirs systems. The water would be diverted between the months of December and May as with the Shepaug Diversion. This alternative if constructed in 1990 would alleviate the projected deficits at Danbury, Stamford and Greenwich through the year 2010.

The second alternative plan would include diversion of water only to the Danbury System. The water could be diverted through an 18 mile long, 36 inch pipeline. The plan would include diverting 4.7 mgd to the Margerie and West Lake reservoirs. The total cost of this plan would be $14.35 million.

West Aspetuck Diversion *

	Danbury	Stamford	Greenwich	Total
Alternative 1				
Safe Yield	2.2 mgd	1 mgd	1.5 mgd	4.7
Total Cost	$6.65	$9.65	$7.60	$23.9
Annual Cost	$ .65	$ .90	$ .80	$2.35
Alternative 2				
Safe Yield	4.7			4.7
Total Cost	$14.35			$14.35
Annual Cost	$ 1.35			$1.35

* All Safe Yields in mgd
All costs in $ millions

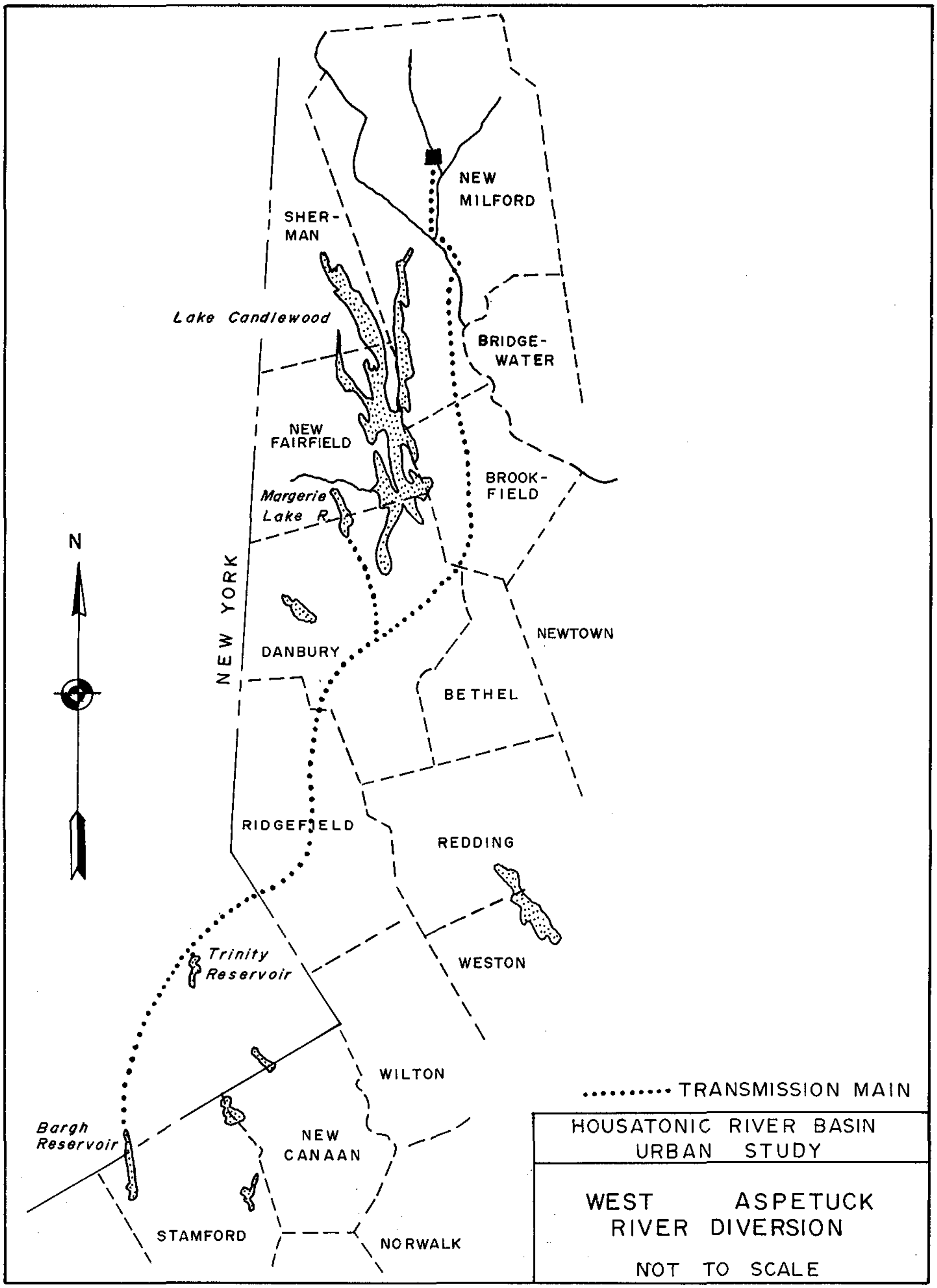

NEW MILFORD
SHERMAN
Lake Candlewood
BRIDGEWATER
NEW FAIRFIELD
BROOKFIELD
Margerie Lake R.
N
NEW YORK
DANBURY
NEWTOWN
BETHEL
RIDGEFIELD
REDDING
Trinity Reservoir
WESTON
WILTON
TRANSMISSION MAIN
Bargh Reservoir
NEW CANAAN
STAMFORD
NORWALK
HOUSATONIC RIVER BASIN URBAN STUDY
WEST ASPETUCK RIVER DIVERSION
NOT TO SCALE

PLATE B-6

Danbury Water Department.

The Danbury Water Department is the major supplier of water to the City of Danbury. It serves 35,000 people which is over one-half of the total population of Danbury. The present average day demand on the system is 7.2 mgd which is expected to increase to 8.8 mgd by the year 2000, and up to 11.4 mgd by the year 2030. The total safe yield of the system 6.5 mgd and is obtained from the West Lake and Margerie Lake Reservoir Systems (see Plate B-7). The Margerie Lake System includes diversions from East Lake and Pandanaram Reservoir into the Margerie Lake Reservoir. The Margerie system has a drainage area of approximately 2.76 square miles and can store 1,534 million gallons of water. The West Lake System diverts water from Bogs Pond, Upper Kohanza Lake and the Lower Kohanza Lake into the West Lake reservoir. This system has a drainage area of 4.05 square miles and can store up to 1,371 million gallons of water. The West Lake Reservoir system also obtains water from Lake Kenosia Wellfield. The Lake Kenosia Wellfield can supply up to 2 mgd but the Department of Health Services feels it has serious potential contamination problems, therefore the safe yield of the wellfield has not been added to the total safe yield of the system. Projected deficits for the year 2000 is 2.3 mgd and for the year 2030 its 4.9 mgd. The following water supply plans have been investigated and evaluated to eliminate these deficits.

The Ball Pond Brook Diversion shown on Plate B-8, is a two phase plan to pump the Ball Pond Brook, which is located in New Fairfield, into the existing Margerie Lake Reservoir. This alternative was first identified in a November 1973 feasibility report by Roald Haestad Inc. Phase I of the plan to be implemented in 1985 (includes) a diversion structure and pump station located on Ball Pond Brook in the vicinity of Gillotti Road. A 1500 foot long, 24 inch diameter transmission main would be extended to Margerie Lake Reservoir. This phase would increase the safe yield of the Margerie Lake System by approximately 1.9 mgd, which would eliminate the projected deficit through 1995. Phase II of the plan would include another diversion structure and pump station on Ball Pond Brook near Lake Candlewood. A 6000 foot long 20 inch force main would be necessary to carry the water to Margerie Lake Reservoir. Margerie Lake would have to be raised 3 feet to provide adequate storage for the second phase of this plan which would provide an increased safe yield of 1.8 mgd, and would alleviate the deficit through the year 2015. The total cost of Phase I is approximately $566,000 and the total cost of Phase II is $4.7 million.

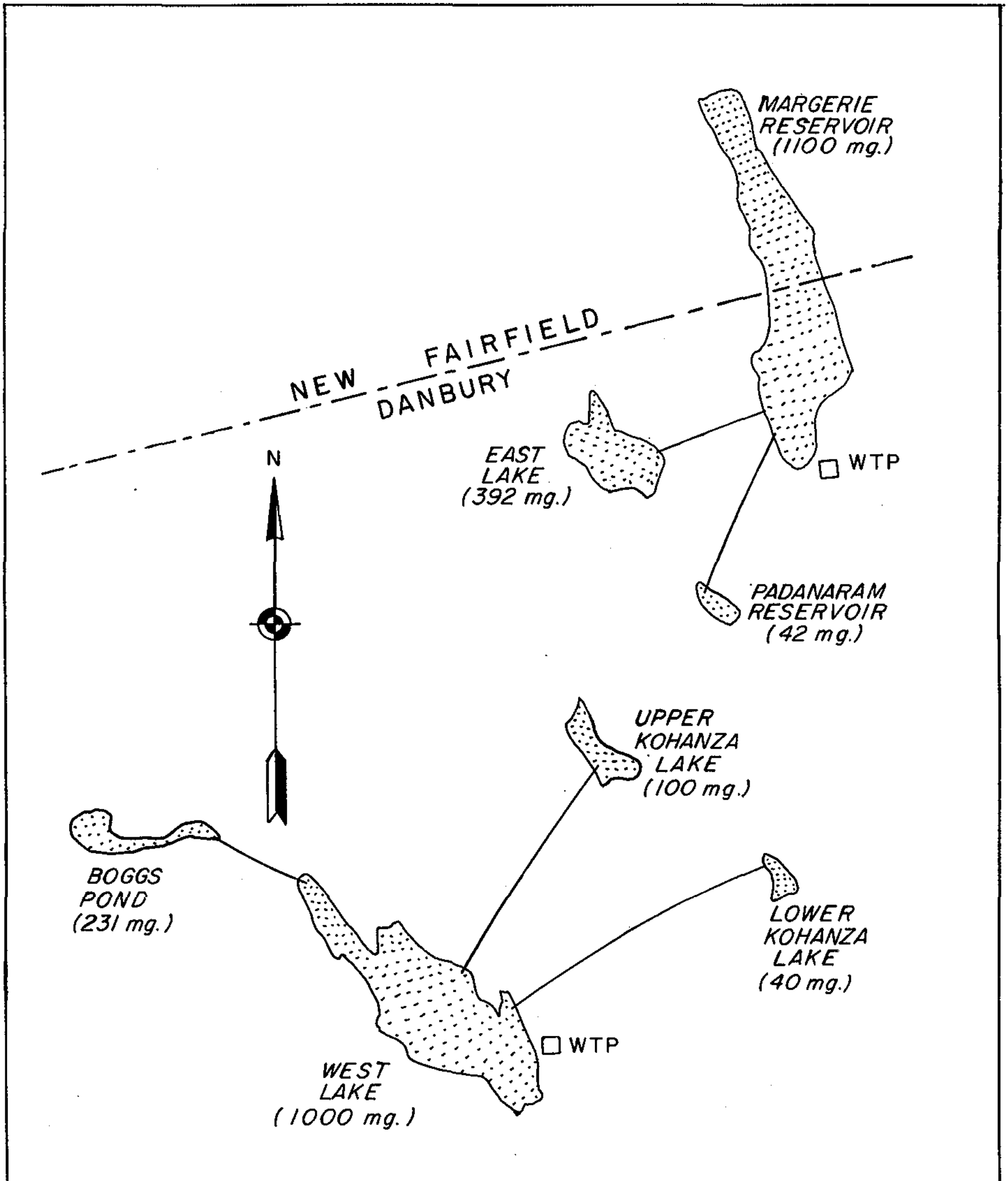
Another diversion plan for Ball Pond Brook was investigated. It is also a two phase plan, but involves diverting water from one location for both phases. Phase I of this plan incudes a diversion structure and pump station located on Ball Pond Brook near Lake Candlewood. A 6,000 foot long 20 inch transmission main would be extended to Margerie Lake Reservoir to transport the water. Phase I of this plan would also provide an increase in safe yield of 1.9 mgd. Phase II of this plan would involve diverting another 1.8 mgd through the same pipeline and diversion structure, which makes it necessary to increase the capacity of the pump station and also raise Margerie Lake 3 feet. The total cost of Phase I of this plan is approximately $869,000 and Phase II about $3.9 million.

The Sugar Hollow Aquifer is located in the southwestern corner of Danbury as shown on Plate B-9. The aquifer covers a 1.2 square mile area which is at present lightly developed: one small light industry and a dozen scattered commercial establishments along Route 7, and low density single family homes along Starrs Plain Road. Potential land use problems, however, exist here: more than three-fourths of the primary recharge area has been zoned for industrial and commercial development. If properly developed this aquifer could yield up to 0.5 mgd. A wellfield and pump station has been designed for the aquifer along with a 1300 foot long, 6 inch transmission main to transport water to the Danbury system. The total cost of this alternative is estimated to be $372,000. One potential problem with the development of this aquifer is that it is located on the Saugatuck River upstream of the Saugatuck Reservoir which is owned and operated by the Bridgeport Hydraulic Company. They have indicated by taking one-half million gallons a day out of this aquifer it could decrease the safe yield of their reservoir by one-half million gallons a day. If this is the case they would want to be compensated in some way for the water being withdrawn.

Other groundwater plans have been investigated including the Brookfield Aquifer, the Pootatuck Aquifer and the Upper Saugatuck River Aquifer. Costs to develop these aquifers and transport the water to the Danbury System were estimated. But, because of the small potential yield of these aquifers and the great distance they had to be pumped they were not very cost effective options and thus were dropped from further consideration.

The Lake Kenosia Diversion which was recently studied by Roald Haestad, Inc. has a potential safe yield of 2.1 mgd. The alternative includes construction of a 24 inch transmission main and pump station that will connect with the existing 24 inch transmission main at Kenosia Avenue which runs under I-84 and the railroad to Millplain Road. A new 24 inch force main would then be constructed from Millplain Road past the Western Connecticut Campus on Driftway Road and on into West Lake Reservoir. This alternative is shown on Plate B-10. The plan is in the process of being implemented and will therefore eliminate any deficit for the Danbury Water Department through the year 2000.

A water conservation report prepared by the Connecticut Department of Environmental Protection was undertaken for this study. There are a couple of alternative measures identified in the report that have potential to save water for the Danbury Water Department. The first includes the use of water saving appliances as a potential conservation measure. It was asssumed that all existing homes and new homes built would be installed with low flow shower heads, and toilets. Implementation of this measure could provide savings of up to 1.4 million



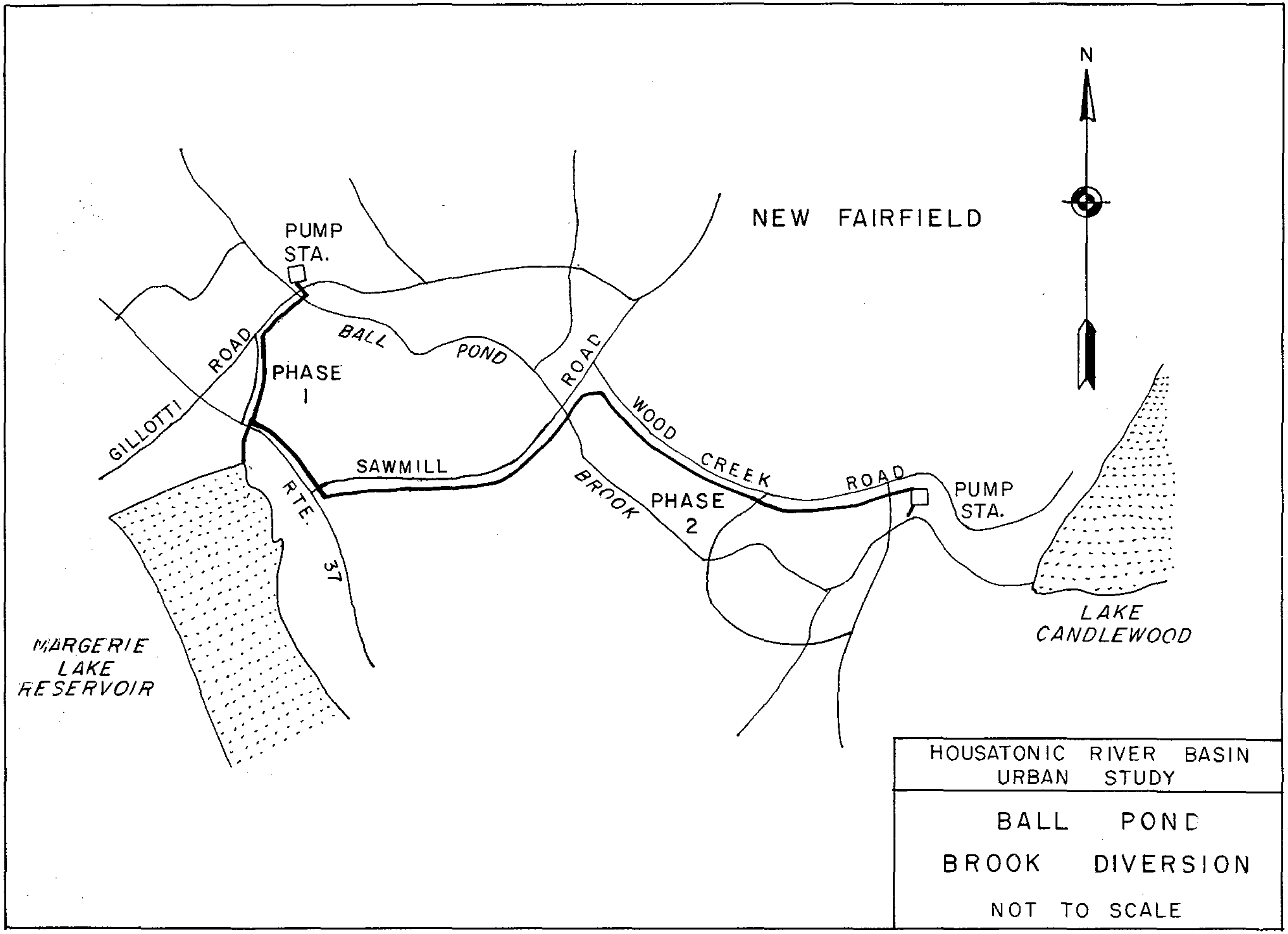
HOUSATONIC RIVER BASIN
URBAN STUDY

DANBURY WATER DEPT.

S.Y. = 6.5 mgd

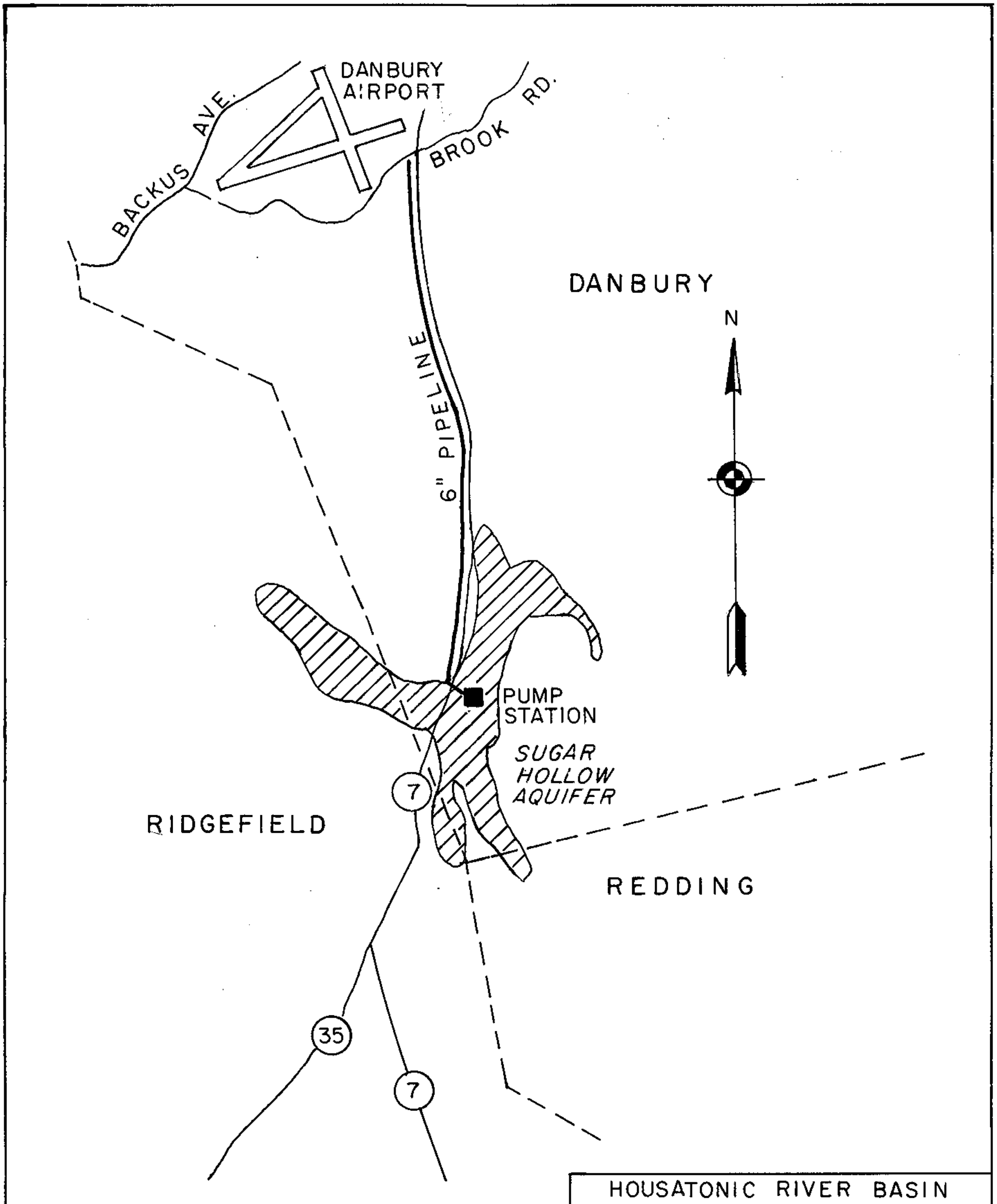
NOT TO SCALE

PLATE B-7



NEW FAIRFIELD
N
PUMP
STA.
BALL
POND
ROAD
GILLOTTI
ROAD
PHASE
1
SAWMILL
RTE.
37
ROAD
WOOD
CREEK
ROAD
BROOK
PHASE
2
PUMP
STA.
LAKE
CANDLEWOOD
MARGERIE
LAKE
RESERVOIR
HOUSATONIC RIVER BASIN
URBAN STUDY
BALL POND
BROOK DIVERSION
NOT TO SCALE

PLATE B-8

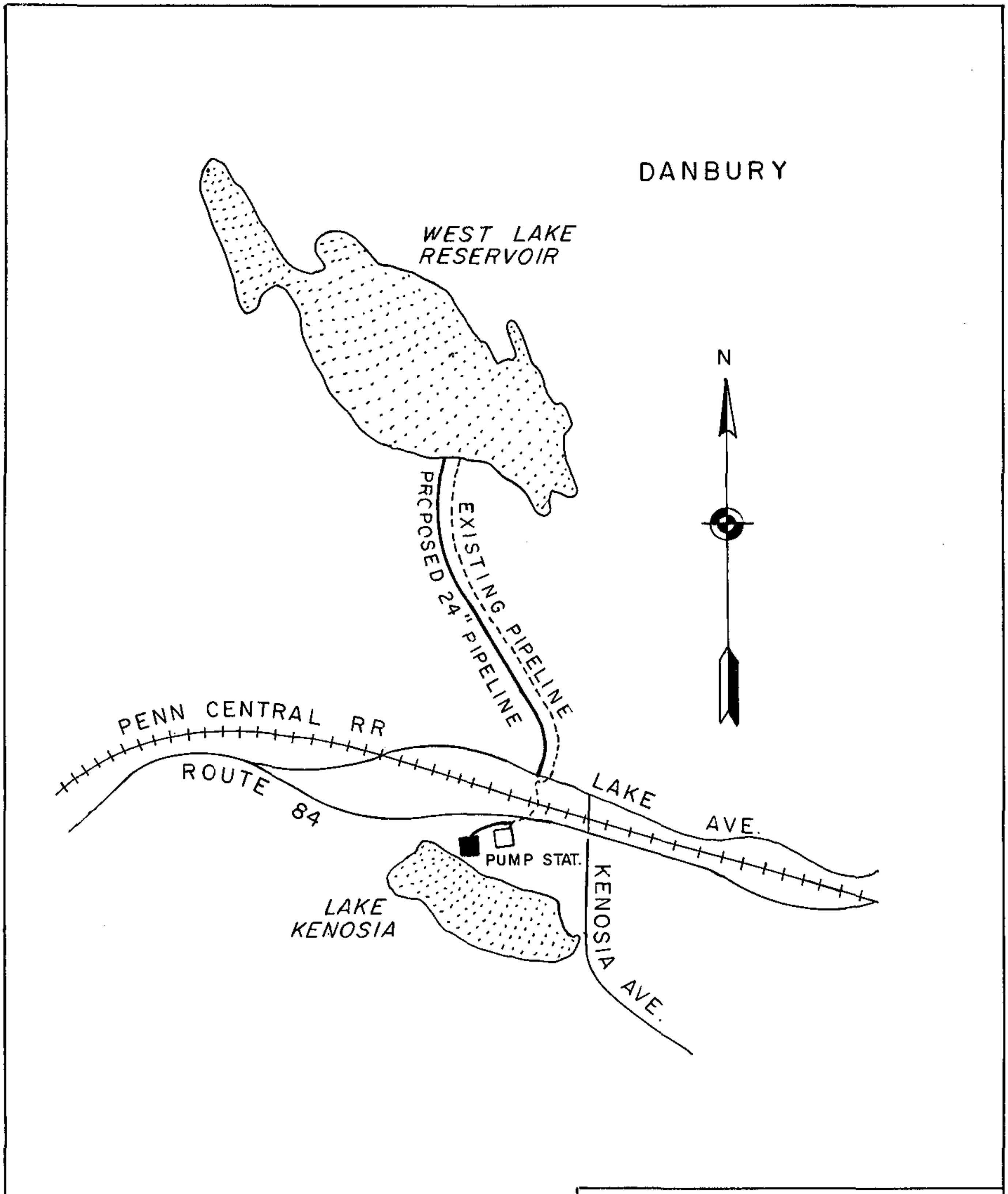


HOUSATONIC RIVER BASIN
URBAN STUDY

SUGAR HOLLOW
AQUIFER

NOT TO SCALE

PLATE B-9



HOUSATONIC RIVER BASIN
URBAN STUDY

LAKE KENOSIA
DIVERSION

NOT TO SCALE

PLATE B-10

gallons a day by the year 2000 and up to 1.5 million gallons a day by 2030. Implementation of a leak detection and repair program is beneficial for any water system with over 15 percent unaccounted for water. Meters are presently being installed in the Danbury system. Upon completion if it is shown that the unaccounted for water amounts to more than 15 percent it would be worthwhile to implement the leak detection and repair program. Both of these measures have potential to save water over the long-term. Another measure which is very effective in reducing consumption over the short-term is an intensive education and restrictions program. This can be implemented during time of drought and can save up to 25 percent of the average day usage. For instance in the existing system 1.8 million gallons per day could be saved through an intense educational program. In the year 2030 up to 2.85 million gallons per day could be saved. Many other water conservation measures were investigated but, the ones discussed here have the potential to provide worthwhile savings to the Danbury Water Department.

The following table delineates the major alternatives evaluated. The first column identifies the alternative, the second column identifies the total cost for the alternatives, the third column identifies the safe yield and the fourth column shows the total cost per million gallons per day.

	Total Cost	Safe Yield	Cost per mgd
Ball Pond Diversion (Phase 1)	$ 566,000	1.9	$ 302,000
Sugar Hollow Aquifer	372,000	0.5	744,000
Ball Pond Diversion (Phase 2)	4,700,000	1.8	2,600,000
Shepaug Diversion	9,200,000	4.0	2,300,000
West Aspetuck Diversion	6,650,000	2.2	3,022,000
Lake Kenosia Diversion	*	2.1	

*recently added to the Danbury system

Ridgefield Water Company

The Ridgefield Water Company, which is the largest in the town, presently serves about 65 percent of the population. As identified in the Problem Identification Appendix the Round Pond Reservoir has been shut down, which means their primary source of water is the Osceletta wellfield which has a safe yield of about 0.77 million gallons a day. Their existing average day usage is about 0.75 mgd and is expected to increase about to 1.05 mgd by the year 2000 and up to 1.47 mgd by the year 2030. This would cause a deficit of about 0.3 mgd by the year 2000 and 0.7 mgd by the year 2030.

Two groundwater sources were investigated for possible use by the town of Ridgefield. The first being Sugar Hollow Aquifer and the second the Upper Saugatuck Aquifer. Plate 6 in the Main Report shows the location of these 2 aquifers. The Sugar Hollow Aquifer has a potential yield of about 0.5 mgd. In order to connect this aquifer with the Ridgefield system it would require 3.5 miles of pipe 8 inches in diameter. The total cost of this alternative including pump station, wellfield and transmission main is $478,000.

The Upper Saugatuck Aquifer which is located in the northern portion of Redding has approximately a 1.5 square mile area. The area is lightly developed including extensive wetlands, a small retail shopping area at the west end and scattered low density residentials. The aquifer has a potential safe yield of 0.5 mgd. The cost of the wellfield, pump station and transmission main to transport this water 5.5 miles to the Ridgefield System is $717,000. An 8 inch force main would be required as in the Sugar Hollow Aquifer alternative. The Upper Saugatuck Aquifer, like the Sugar Hollow Aquifer, is also located in the watershed of the Saugatuck Reservoir. If 0.5 mgd is drawn from this aquifer, it may decrease the safe yield of the Saugatuck Reservoir by that much.

A possible interconnection between Danbury and Ridgefield was also investigated. It was designed to carry up to 1 mgd of water. The transmission main would be 12 inches in diameter and extend 7 miles to interconnect the two systems. The cost of the interconnecting pipeline and pump station is $1,358,000. This cost does not include any cost for water which would have to be bought from the Danbury Water Department.

Water Conservation was also investigated for the town of Ridgefield The Ridgefield Water Company has 26 percent unaccounted for water. About half, or 0.09 mgd, could be saved through implementation of a leak detection and repair program. Another conservation measure that appears feasible over the long-term is the installation of water saving devices. It appears that this measure could save up to 0.3 mgd immediately, as much as 0.4 mgd in the year 2000 and 0.5 mgd in the year 2030. Also during a drought situation a potential savings of 0.2 mgd could be obtained through an intense education program in conjunction with restrictions.

The following table identifies a major alternatives evaluated for the Ridgefield Water Company.

	Total Cost	Safe Yield	Cost per mgd
Sugar Hollow Aquifer	$ 478,000	0.5 mgd	$ 956,000
Upper Saugatuck Aquifer	717,000	0.5 mgd	1,434,000
Danbury Interconnection	1,358,000*	1.0 mgd	1,358,000*

* Does not include the cost of water, only the interconnection with the Danbury Water Department.

Greenwich Water Company. The Greenwich Division of the Connecticut American Water Comapny supplies water to the town of Greenwich in Connecticut and to Port Chester Water Works Inc, in New York. The present total average day demand is 16.7 mgd of which approximatley 7 mgd is sold to Port Chester. The demand for the year 2000 is expected to increase to 17.3 mgd and by 2030 to 19.6 mgd. These projected demands assume that Port Chester will continue to buy 7 mgd from Greenwich. If they do, Greenwich will have a 0.3 mgd deficit by the year 2000 and a 2.6 mgd deficit by 2030. The present safe yield of the system is approximately 17 mgd. Their source of water comes from four separate reservoirs which are all interconnected: Bargh Reservoir, which is the largest, Brush Reservoir, Rockwood Lake and Putnam Lake. A map of the system is shown on Plate B-11. The system can store a total of 3,536 million gallons and has a drainage area of over 25 sq. miles.

The Mianus Pond was investigated as a potential future source for drinking water. The pond is located at the mouth of the Mianus River in Greenwich and has a total capacity of 275 million gallons. The impoundment has a total watershed of over 12 square miles and is estimated to have a safe yield of approximately 2.5 mgd. There is an existing dam owned by Conrail but is expected to be abandoned in the near future. This is presently a Class A water body and the Department of Environmental Protection indicates it can be upgraded to it Class AA through the standard revision process. A map of this alternative is shown on Plate B-12.

The alternative plan involves the construction of an 8,000 ft. long 18 inch transmission main from Mianus Pond up to the existing Mianus River Filtration Plant. The total cost of this alternative is $1,020,000 and includes a pump station and transmission main. In order for this alternative to increase the safe yield of the system by the full 2.5 mgd the existing filtration will have to be expanded and some changes made in the distribution system. This plan would eliminate the projected deficits through the year 2030.

Another alternative investigated is the possible diversion of water from the East Branch of the Mianus River in Stamford into the existing Bargh Reservoir (shown on Plate B-13). This alternative could increase the safe yield of the system by as much as 1 mgd which would supply their needs till 2010. A diversion of this size into the existing system would not require any additonal storage. The alternative includes a diversion structure on the East Branch of Mianus River, a pump station, and an 18 inch force main 7,040 feet long to the existing Bargh Reservoir. The total cost of this alternative is about $730,000 and a diversion of this size on the East Branch Mianus River is not expected to cause any severe adverse environmental impacts.

The Bargh Reservoir is a water supply reservoir providing potable water to the residents of Greenwich. The existing dam is an earth filled embankment with a top elevation of 262 NGVD. The reservoir has a storage capacity of 7,515 acre feet and a safe yield of 10.2 mgd. The drainage area contributing to the Bargh Reservoir encompasses a total of 18.3 square miles. The surface area of the lake at normal storage level is 230 acres.

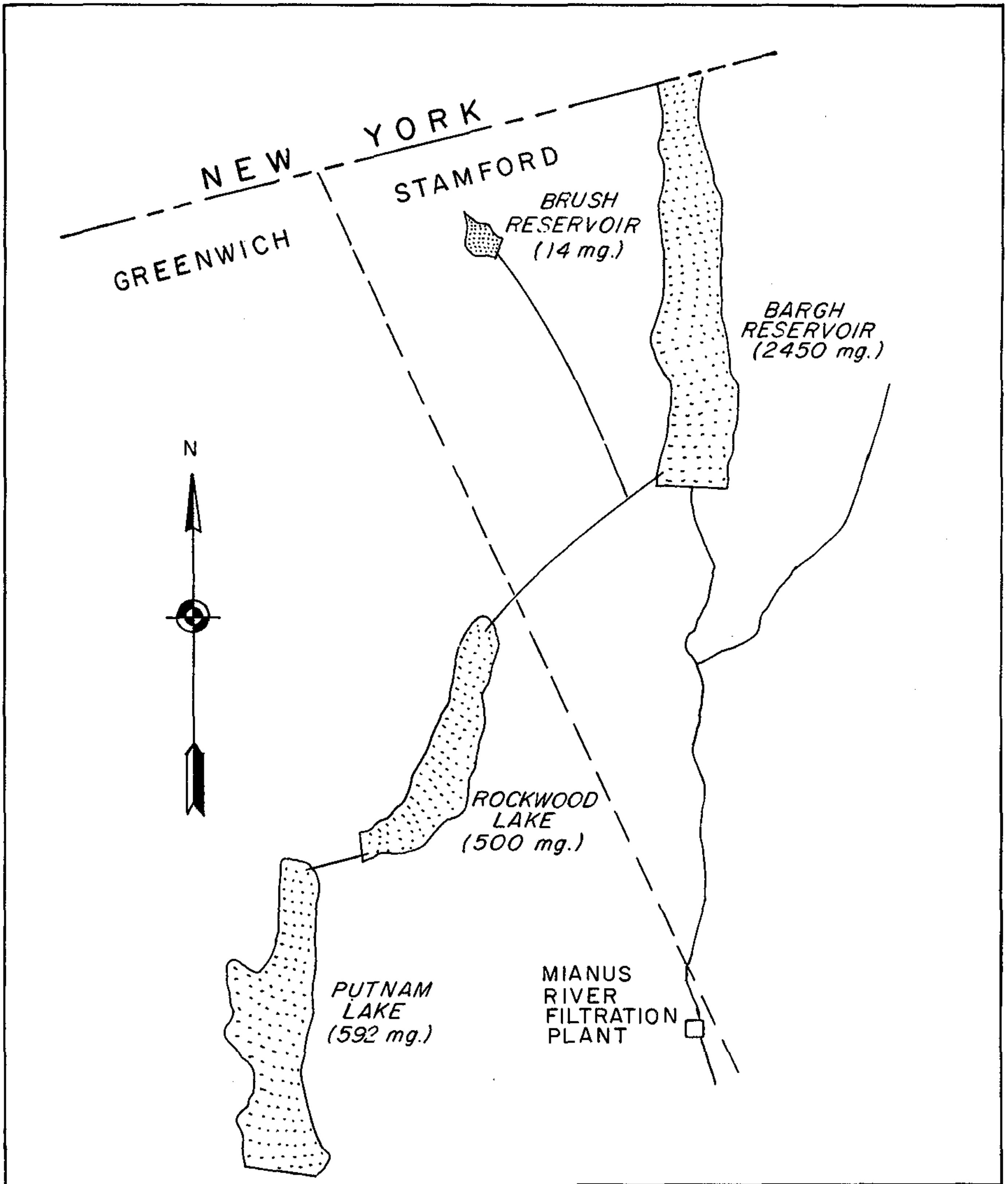
Preliminary analysis indicates that a safe yield of 13.2 mgd could be obtained from the 18.3 square mile drainage area if adequate storage were available in the reservoir. In order to increase the storage of the reservoir to the required 12,475 acre feet, the dam would have to be raised 20 feet to elevation 282. This plan would increase the surface area by 36 acres.

Located upstream of the Bargh Reservoir lies the 400 acre Mianus River Gorge Wildlife Refuge and Botanical Preserve, which is owned by the Nature Conservancy, a national conservation organization. The Mianus Gorge was the pioneer project of the Nature Conservancy and also this country's first National Landmark. The Preserve is also the site of a New York State endangered plant species, Stone's violet, and is currently the only site in the State from which a specimen has been collected. Along with these rare plant species, the Mianus Gorge area has a lengthy list of over 200 species of observed wildflowers among which include the showy orchids and the stemless lay's-slipper orchid. According to a State botanist, none of these rare plants or wildflowers will be inundated by the rise in water level of the reservoir.

The vegetation of the Mianus River Gorge Preserve consists of a relatively mature forest community and several stages in the succession of plants leading up to this mature phase. Certain species are characteristic of the transitional vegetational stages, whereas others are found only in the mature forest. Examples of the former group are gray birch, bayberry, red maple, sumach, sassafras, wild black cherry, sweet birch and honeysuckle, while important species in the mature forest are beech, hemlock and several kinds of oaks. The gorge is a naturalist's delight for its variety of fauna and flora, including a forest of tall hemlocks. This stand of trees is called the Hemlock Cathedral and comprises 20 acres of steep hillside covered with virgin eastern hemlocks. Two of the giant hemlocks, each four feet in diameter at chest height, date back to the 1680's.

The New York State Department of Environmental Conservation presently stocks the Mianus River with brook and brown trout. Other common fish species found in the Mianus River include minnows, suckers, catfish, eels, sunfish, perch and pike.

The wildlife species identified within the project boundaries include many species of birds, mammals and reptiles. The venomous reptiles are copperhead snakes. Much of the land proposed to be inundated is habitat for many wildlife species. The State reviewed the project for potential impacts on significant fish and wildlife habitats in the Bargh Reservoir area and found no apparent conflicts with endangered fish or wildlife species or other significant habitats for which there are records.



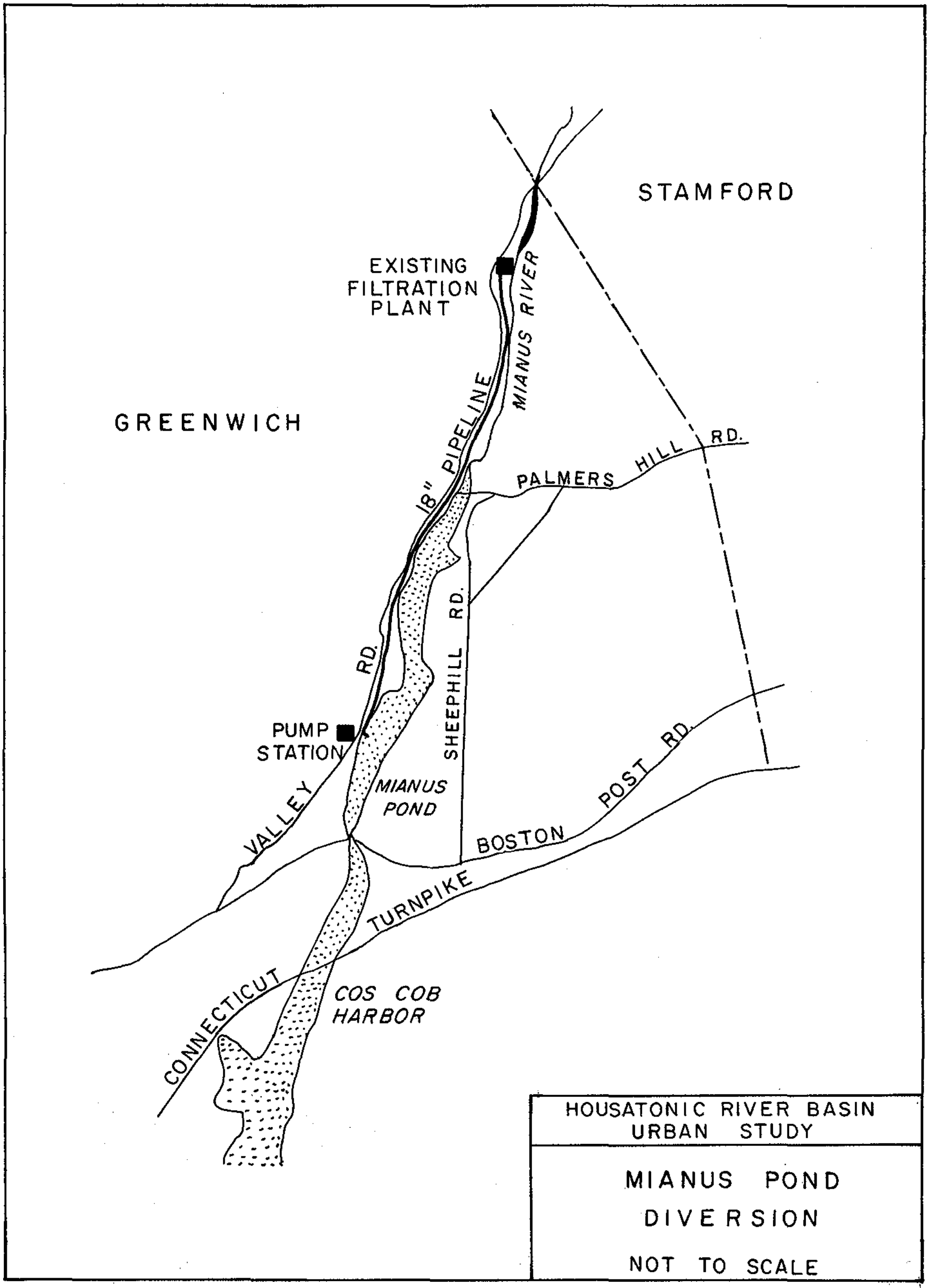
HOUSATONIC RIVER BASIN
URBAN STUDY

GREENWICH WATER CO.

SAFE YIELD = 17.0 mgd

NOT TO SCALE

PLATE B-11

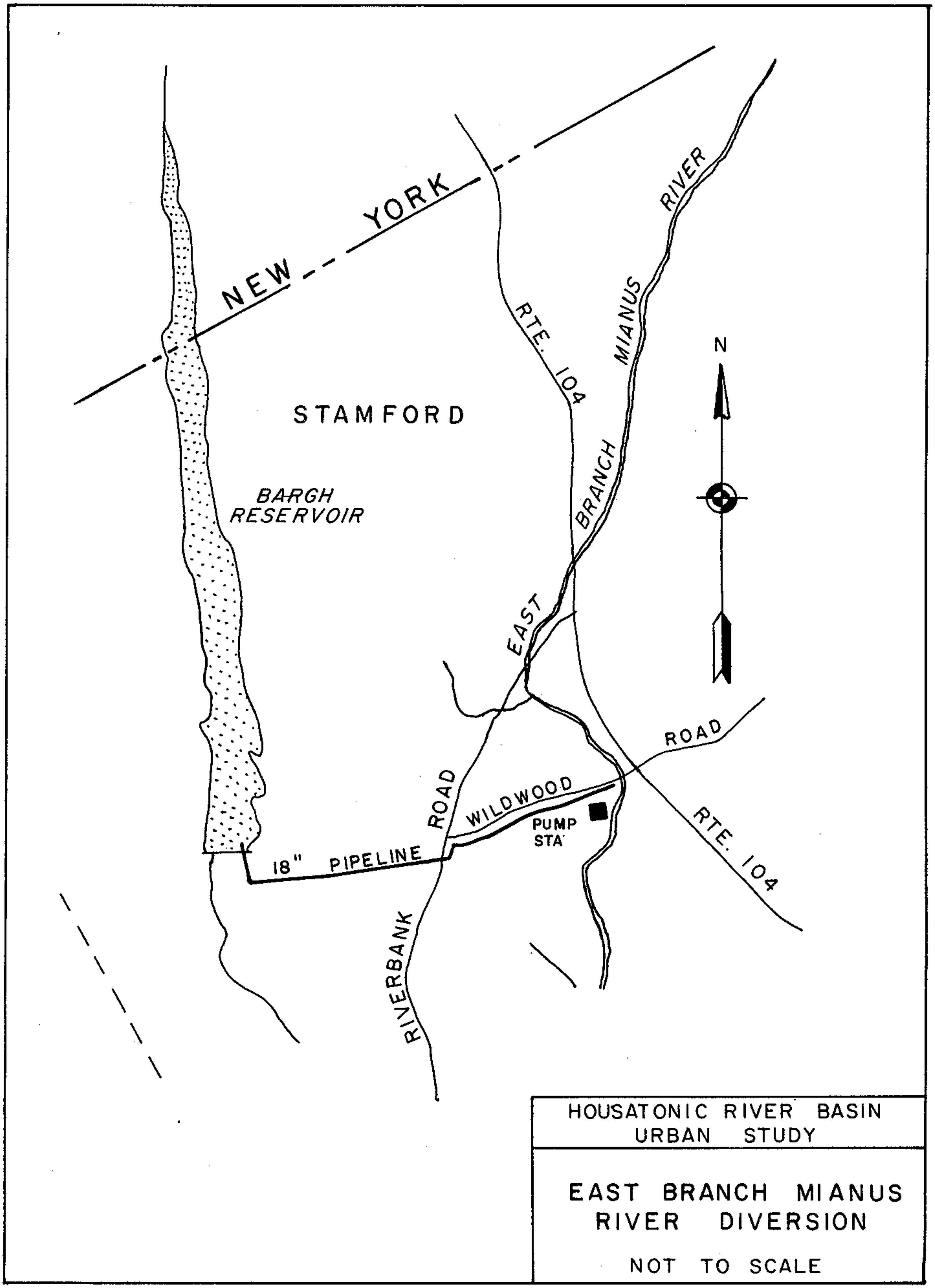


HOUSATONIC RIVER BASIN
URBAN STUDY

MIANUS POND
DIVERSION

NOT TO SCALE

PLATE B-12



HOUSATONIC RIVER BASIN
URBAN STUDY

EAST BRANCH MIANUS RIVER DIVERSION

NOT TO SCALE

PLATE B-13

Rock outcrops exposed in the rapids and lower walls of the Mianus River Gorge probably hold the full explanation of unusual straightness and relief of this feature. Some kind of a fault or fracture zone appears likely inasmuch as the entire gorge is developed in one formation the Bedford Gneiss, which is a biotite-quartz-plagioclase gneiss with interlayered amphibolite, in part with augen of andesine and microline. Large pink microline augen, up to one inch in size, and smaller white plagioclase crystals are roughly aligned in a generally dark-gray or black, well foliated matrix, giving the rock a distinctive appearance.

The total cost of the alternative to raise the Bargh Reservoir the required 20 feet is approximately $8.0 million. If built, this plan would have severe social and environmental impacts due to the flooding of a portion of the Mianus Gorge Area. The following table identifies and compares the various alternatives studied for the Greenwich Water Company.

	Total Cost	Safe Yield	Cost per mgd
Mianus Pond	$1,020,000	2.5	$ 408,000
E. Branch Mianus River	730,000	1.0	730,000
Raising Bargh Reservoir	8,000,000	3.0	2,666,000
W. Aspetuck Diversion	7,580,000	1.5	5,053,000
Shepaug Diversion	13,150,000	2.5	5,260,000

The water conservation report, also investigated water conservation for the Greenwich system. Whereas, unaccounted for water in the Greenwich Water system is approximately 17 percent, a leak detection and repair program appears feasible at this time. A leak detection and repair program if implemented now could probably save around 3 mgd but as the system gets older more and more water can be saved through such a program. The state also investigated the possibility of fitting all existing and future homes with low flow showerheads and also low flow toilets. This would effectively save 1.8 million gallons a day in the year 2000, and up to 2 mgd in the year 2030. These two measures can provide long term savings over the next 50 years. Another method of conservation that has proven effective for the Greenwich system is an education and restrictions program. If implemented in 1981 it could save about 30 percent of the average day demand, but is only effective for short periods of time.

Stamford Water Company

Stamford Water Company delivers water to about 84,000 people in Stamford and also supplies water to the Noroton Division of the Connecticut American Water Company in Darien. The system supplies an average of about 15 million gallons per day, about 14 mgd goes to Stamford customers and 1 mgd to the Noroton system. The projected demand for the City of Stamford is expected to increase to 16 mgd by 2000 and up to 20.4 mgd by the year 2030. The Stamford Water Company obtains its supply from 5 reservoirs as shown on Plate B-14. The reservoirs can store 4912 million gallons of water from a drainage area of 21.5 square miles. The system produces a safe yield of 17.5 mgd. This system presently can take care of the needs of the Stamford system through the year 2000. By the year 2030 the water company will have to increase its safe yield by 3 million gallons a day, and if they continue to serve Noroton by 5 mgd.

The Siscowit Reservoir is a water supply storage reservoir providing potable water to residents of Stamford and Darien, Connecticut. To meet future needs a plan was investigated to raise the level of the reservoir by 25 feet, consisting of the construction of an earth and rock dam at the site of the existing impoundment (see Plate 8 in the Main Report). The top length of the dam would be approximately 1650 feet. In addition, a dike would be constructed with a top length of approximately 650 feet. The elevation at the top of these structures is 482.

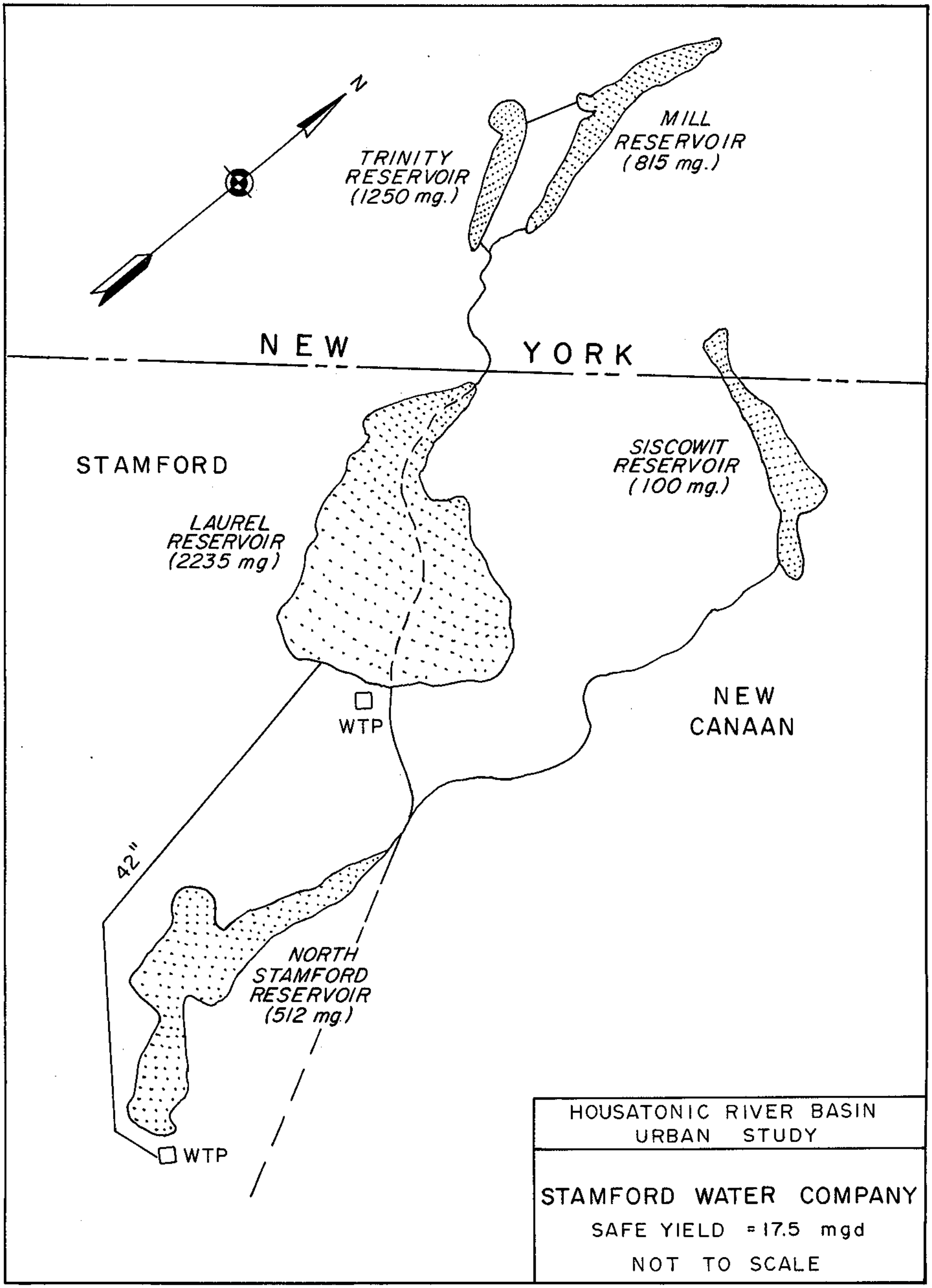
The drainage area contributing to the Siscowit Reservoir encompasses a total of 3.4 square miles. Based on storage capacity curves it is estimated that this watershed could supply a maximum safe yield of about 2.7 mgd. The Siscowit Reservoir presently yields about 0.7 mgd. This plan requires a reservoir surface elevation of 473. With the resulting increased water surface area (175 total acres), it would be necessary to purchase 128 acres of land and relocate three houses. Formulation of this plan indicated a project cost of $9.6 million.

Approximately 27 acres of wetland habitat will be lost as a result of raising the Siscowit Reservoir 25 feet.

Regional records indicate the presence of a warm water fishery in the reservoir which would include largemouth and smallmouth bass, yellow perch, white perch, chain pickerel, brown bullhead, northern pike and common sunfish. The reservoir is not heavily fished at the present time because of limited public access. This enlarged surface area would be beneficial to the warm water fishery allowing the fish to either grow larger individually or to extend their population in numbers.

There have been no endangered or rare flora or fauna species sighted in the area. Deciduous trees and shrubs along the shoreline will have to be removed when the impoundment surface is raised, but a buffer tree line at the new level will have to be retained in order to maintain stability of the new impoundment.

The water conservation report indicates that unaccounted for water in the Stamford System is about 9 percent therefore, a leak detection and repair program was considered to be of minor benefit. The installation of water saving devices could be of some benefit in the future. Preliminary indications are that up to 2.6 million gallons a day could be saved by the year 2030, whereas, the total deficit is only 3 for the Stamford area in the year 2030, this could be very significant. The other measure that could be significant for this system is education and restrictions and could save up to 4 to 5 million gallons a day but only on a short-term



HOUSATONIC RIVER BASIN
URBAN STUDY

STAMFORD WATER COMPANY

SAFE YIELD = 17.5 mgd

NOT TO SCALE

PLATE B-14

basis. The following table identifies the various alternatives investigated for the Stamford Water Company.

	Total Cost	Safe Yield	Cost per mgd
Shepaug Diversion	$19,860,000	4.5	$4,413,000
Raising Siscowit Reservoir	9,600,000	2.0	4,800,000
West Aspetuck Diversion	9,650,000	1.0	9,650,000
Bridgeport Hydraulic	1,450,000	2.0	725,000

Norwalk 2nd Taxing District

The Norwalk 2nd Taxing District, water department presently serves about one-half of the population of Norwalk. They presently serve about 5.1 million gallons a day to their customers. The demand on the system is expected to increase to 5.8 million gallons a day by the year 2000 and up to 7.5 million gallons a day by 2030. The safe yield of their system is 4.5 million gallons a day and is obtained from 3 reservoirs as shown on Plate B-15. Streets Pond and Rock Lake Reservoirs flow into the South Norwalk Reservoir (City Lake). The total system can store 850 million gallons of water and has a drainage area of 11.8 square miles. Norwalk 2nd also has a contract with Bridgeport Hydraulic Company to buy up to 3 million gallons a day on an as needed basis. If they were to maintain this contract through out the long-term to the year 2030 they would not require any additional sources to be added to their system. However, Norwalk 2nd is selling approximately 1 mgd to the Noroton system in Darien. Preliminary indications are that the amount of water sold to the Noroton system will increase in the future.

One alternative source that has been investigated for the Norwalk 2nd Taxing District is the Comstock Brook Reservoir (See Plate B-16). This reservoir was initially identified by the Soil Conservation Service. Constructing the proposed Comstock Dam would provide an additional 550 million gallons of storage to the system. Preliminary indications are that the reservoir would cost about $4,000,000 and could add up to 1.1 million gallons a day to the safe yield of the Norwalk 2nd system. This would alleviate their deficits through the year 2000.

Roald Haestad, Inc., recently completed a study of two diversions for the Norwalk 2nd Taxing District. They evaluated the additional safe yield that could be obtained from diversions of the Norwalk and Silvermine Rivers into the Norwalk 2nd Reservoir System. The Norwalk River diversion would include construction of a pumping station at Dana Pond and a pipeline into City Lake. Depending on the size of the pump station and the pumping rate, the safe yield could be increased by as much as 3.1 mgd.

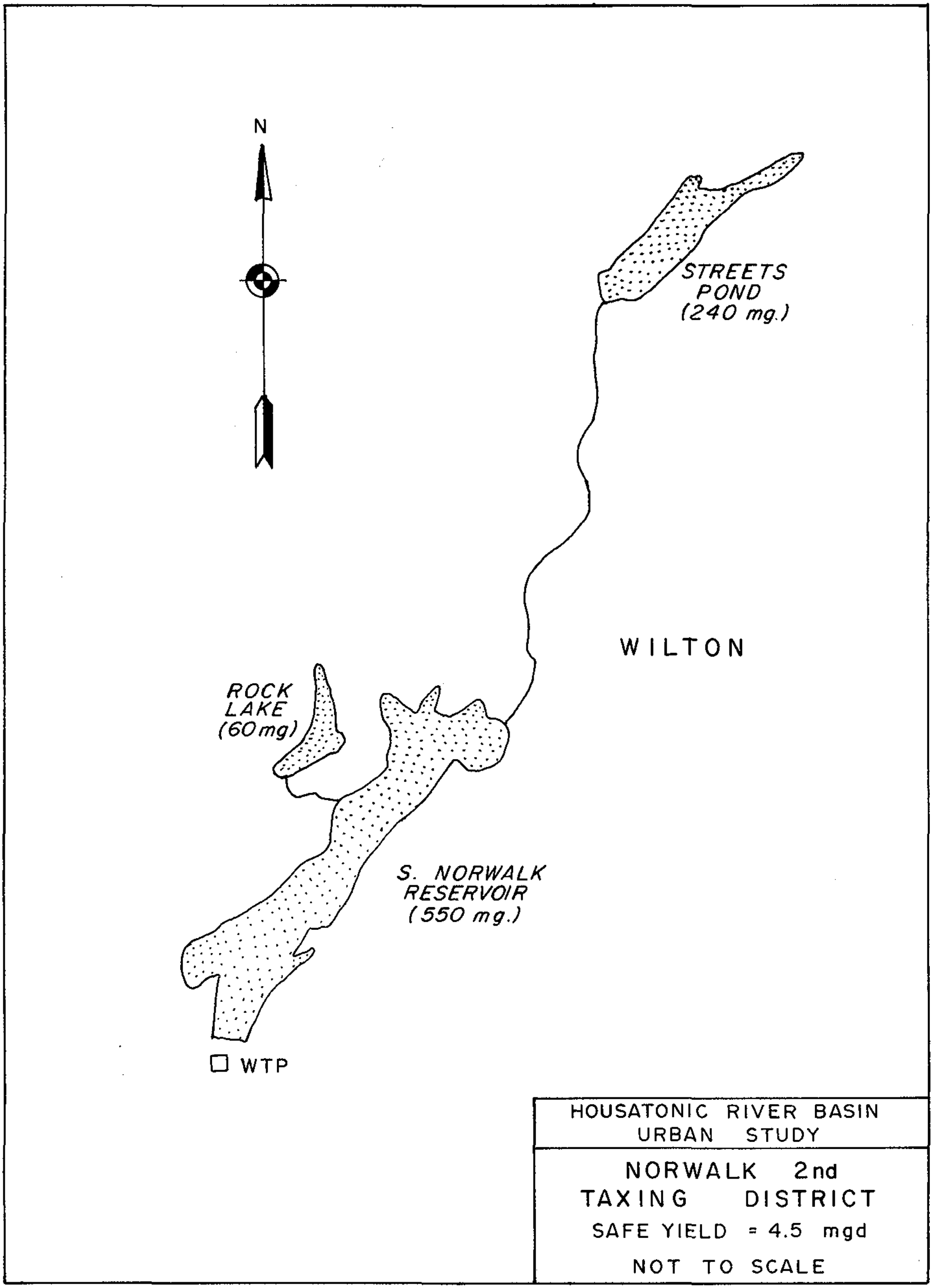
The Silvermine River diversion would include construction of a pump station on the river at Borglum Road and a pipeline into City Lake. The additional safe yield available with this alternative is up to 1.6 mgd, but can be less depending on the pumping rate. Preliminary indications are that the Silvermine River diversion would cost about $1 million and the Norwalk River diversion approximately $500,000.

One major problem that arises with the use of the Norwalk is its water quality classification. The river is presently designated as a Class C river by the State. Existing policies by the State require that for any river to be used as a water supply source it must have a Class AA or Class A designation. With the number of discharges into the Norwalk River, it is doubtful that it could ever be brought up to Class A standards. Upgrading the river to Class A goals would require elimination of all sewage discharges.

The Water Conservation Study indicates that the Norwalk 2nd Taxing District water system has 26 percent unaccounted for water. Implementation of a leak detection and repair program would be successful in saving 0.4 million gallons a day which is 9 percent of the total average day demand. Installation of water saving devices in existing and new homes could save up to 1 million gallons a day by the year 2030. These two measures are good for decreasing the long-term demand through the year 2030. Short-term savings of up to 1.5 million gallons a day can be realized through an educational and restrictions program during time of drought. The following table identifies some of the more feasible alternatives studied for the Norwalk 2nd Taxing District.

Alternative	Total Cost	Safe Yield	Cost per mgd
Bridgeport Hydraulic	0*	3.0	0
Norwalk River Diversion	$ 500,000	3.1	$ 160,000
Silvermine River Diversion	1,000,000	1.6	625,000
Comstock Brook Dam	4,000,000	1.1	3,635,000
Shepaug Diversion	$13,750,000	3.0	$ 4,580,000

*The costs identified in this table are for construction of any new facilities, which are not needed in this case. Norwalk 2nd is still required to pay for finished water from Bridgeport Hydraulic Company.



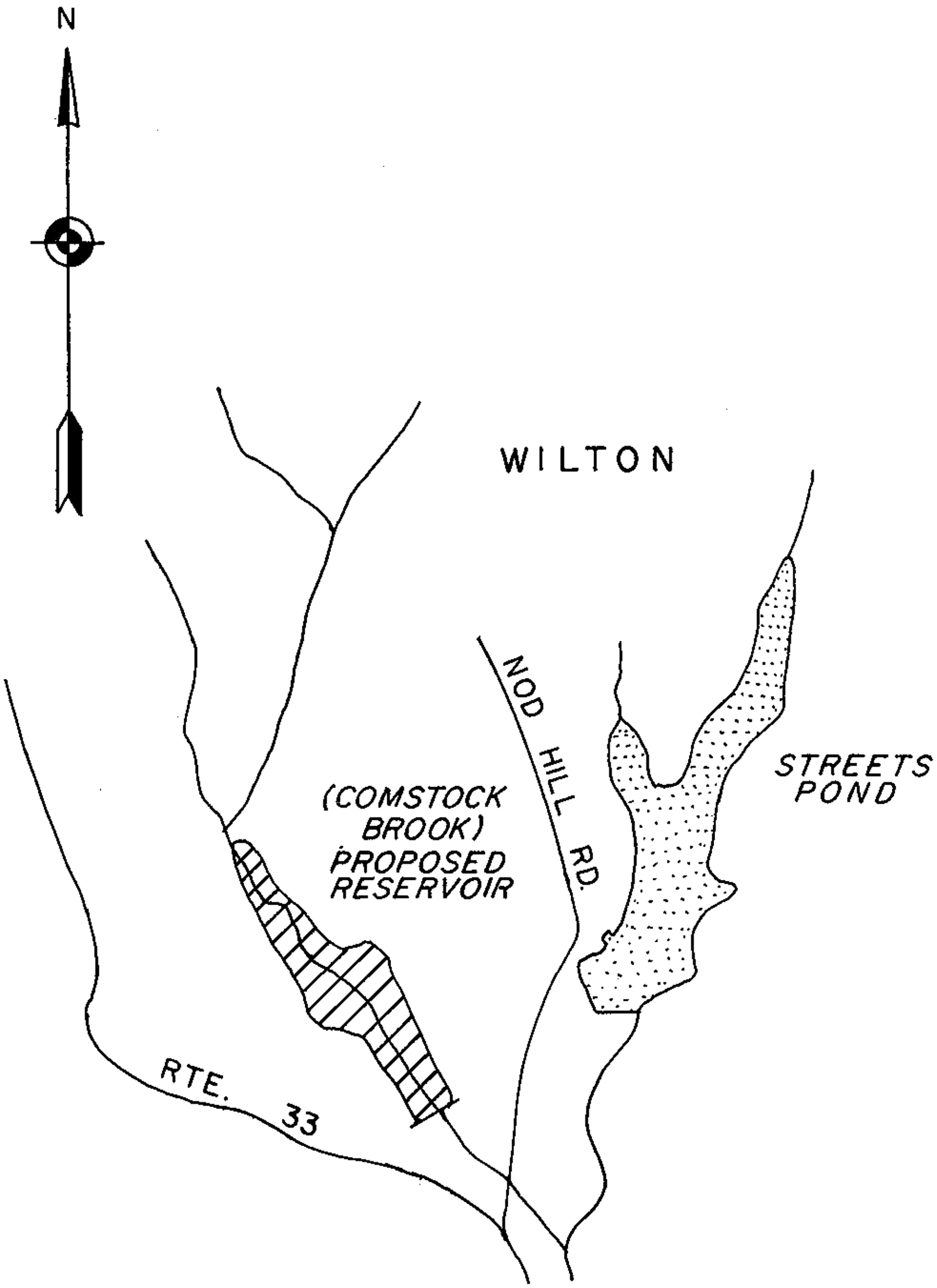
HOUSATONIC RIVER BASIN
URBAN STUDY

NORWALK 2nd
TAXING DISTRICT

SAFE YIELD = 4.5 mgd

NOT TO SCALE

PLATE B-15



HOUSATONIC RIVER BASIN
URBAN STUDY

COMSTOCK BROOK DAM

NOT TO SCALE

PLATE B-16

FLOOD DAMAGE REDUCTION

INTRODUCTION

Intense runoff is the natural consequence of severe rainfall or a combination of rainfall and snowmelt in any river basin. The volume and intensity of rainfall and the rate of snowmelt are beyond human control. Thus runoff will always occur, and mankind can only attempt to control the timing of the runoff from the natural phenomena. Over the years various means to control or avoid damages from flooding have been developed. Today there is a wide spectrum of alternatives available for consideration when developing a flood damage reduction plan for a particular locale. This section of the report attempts to review the complete set of available measures. To aid in the review process it is useful to categorize the alternatives to indicate the relationships between the various strategies. This section is intended to provide a review of the full set of options prior to screening them to fit the problem areas under discussion.

POTENTIAL MANAGEMENT MEASURES

The most common response to a request for a description of two ways to reduce or prevent flood damage would likely be: (1) "build a dam," and (2) "don't build any houses near the river." Both are correct answers, but these alternative measures are fundamentally different in terms of what they are attempting to do and where they would most appropriately be applied. In the case of dam construction, the objective is to store and delay a portion of the runoff from areas upstream of the dam in order to reduce the maximum instantaneous flow at any point below the dam. This in turn should reduce flood damages to existing property that otherwise would be flooded. In the second case of not building near the river, the objective is not to control the flood, but instead to prevent human activity from getting "in the way" of the flood. These two examples represent the initial classification step taken when developing a means to illustrate the relationships between the various alternative measures. The two major categories used are: (1) "Decrease the Flooding," and (2) "Decrease Impact of Flooding." The following illustrates the organization of alternative measures used for this project.

I. Decrease Flooding

   A. Adjust Runoff Rate
   B. Reservoirs
   C. Natural Valley Storage
   D. Divert Flows
   E. Increase Channel Capacity
   F. Removal of Dams
   G. Bridge Modification
   H. Dikes

II. Decrease Impact of Flooding
   A. Flood Proofing
      1. Rearranging Property Within Existing Structure
      2. Closures
      3. Small Walls or Dikes
      4. Raising Structure
      5. Relocation

   B. Flood Warning and Evacuation

   C. Flood Plain Regulation

   D. Flood Insurance

   E. Public Acquisition of Flood Plain Land

ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING

Flood damage reduction measures were evaluated using engineering judgement and brief study of the entire Housatonic River Basin. Each measure was judged on its own merits. Those not considered adequate, feasible, practical or realistic engineering solutions, or those measures socially or environmentally unacceptable or economically unjustified, were eliminated from further study.

The screening process gave consideration to both nonstructural (all regulatory, flood proofing, relocation) and structural (dikes, floodwalls, reservoirs, diversions, etc.) measures.

Decrease Flooding

Adjust Runoff Rate. Peak flows can be decreased by reducing the rate at which water flows over the land towards the streams during a storm. This can be accomplished by measures designed to increase interception of rainfall, such as forestation; measures designed to increase ponding of runoff, such as contour plowing; and measures designed to increase infiltration, such as maintaining loose soils. In urban areas, runoff rates can be influenced by controlling the characteristics of future development. For example, a limit can be set on impervious surfaces such as paved roads and parking lots, which do not allow any infiltration.

The practices designed to adjust the runoff rate are generally inexpensive, and often have beneficial side effects. For example, farming practices such as contour plowing and crop rotation generally improve crop yields as well as decrease runoff rates.

Farming is not that widespread in this area, therefore, practices such as crop rotation and contour plowing will not have any effect on flood stages. The impact of increased urbanization on the flood stages in the Housatonic Basin are very small. For instance, doubling the urban land area above the Coltsville section of Pittsfield would only increase the 100-year flood stage in that area by 0.2 feet. Therefore, this measure is not considered feasible and will not be studied in any more detail.

Reservoirs. Decreasing flood flows through the use of reservoirs was also investigated as a potential measure to alleviate the flooding problem. A reservoir management program was investigated for the upper reaches of the Housatonic River.

The basic element in a reservoir management program is providing additional storage for floodwaters by lowering the stage in existing reservoirs. The New Year's Flood of 1948-1949 served as an example to evaluate the benefits of such a program.

For the purpose of determining effects in this study Ashmere Lake and Plunkett Reservoir were selected for regulation or management. Water supply reservoirs were exempted.

Prior to flood routing, the New Year's Flood, with a reservoir management program in effect, elevations of the pool areas in the affected reservoirs were assumed to have been drawn down as shown in the following table. The increased floodwater storage available below the normal spillway elevation is given in acre-feet.

Reservoir	Pool Elevations (MSL)	Drawdown (FT)	Increased Storage (AC FT)
Ashmere Lake	1575	3.0	500
Plunkett Reservoir	1498	3.0	375

The resulting peak discharges and flood stages under the assumed reservoir management program, compared to those with present conditions, were reduced by very small amounts (0.5 feet or less) at most locations for the 10-year, 100-year and rare floods.

The results of this brief study of reservoir management indicates that the potential for reducing peak flood discharges and flood stages by such a program are negligible.

Reservoir management has not proved to be feasible in the other major damage areas along the mainstem Housatonic because the effects of reservoir management become less and less noticeable as the watershed area becomes larger and larger.

Another method to decrease flood flows is to construct reservoirs upstream of the flood damage areas. Four separate reservoirs were investigated to control potential flood problems in the Pittsfield area. The reservoirs investigated were initially identified in the SCS report, "A Study of Potential Reservoir Sites". The reservoir numbers 307, 308, 310, and 319 are shown on Plate B-17.

Dam number 307 located on the upper portion of Wahconah Falls Brook in Windsor, would have a maximum height of 75 feet and length of 2,955 feet. The total reservoir area subject to inundation is 120 acres. If the dam were constructed, preliminary indications are that it could decrease the 100-year stage in the Pittsfield area by about 1 foot. The estimated cost of this dam would be over $30 million. The annual cost of this reservoir excluding operation and maintenance would be about $2.5 million. The total expected annual damages for the flood areas downstream of the dam are under $1 million and this dam would only eliminate a small portion of those damages, therefore, the dam is not economically feasible.

Dam number 308, which is at the site of the existing Windsor Reservoir, would have a maximum storage of about 4000 acre-feet, be about 68 feet high and 2110 feet long. The reservoir would decrease the 100-year flood stage by over 18 inches in the Pittsfield area. The total cost to construct this reservoir is about $24 million, which yields an average annual cost of $1.9 million. The total estimated annual damages downstream of this site are about $1 million and this dam would also eliminate only a portion of those damages. Therefore this plan is not economically feasible.

The third site, number 310 located on Cady Brook, upstream of Windsor Reservoir could provide a total storage of only 1,265 acre-feet. Because this site would only drop the 100-year flood stage by 6 inches in Pittsfield and would cost almost $14 million, the plan was deemed unfeasible, as were the two previous sites discussed.

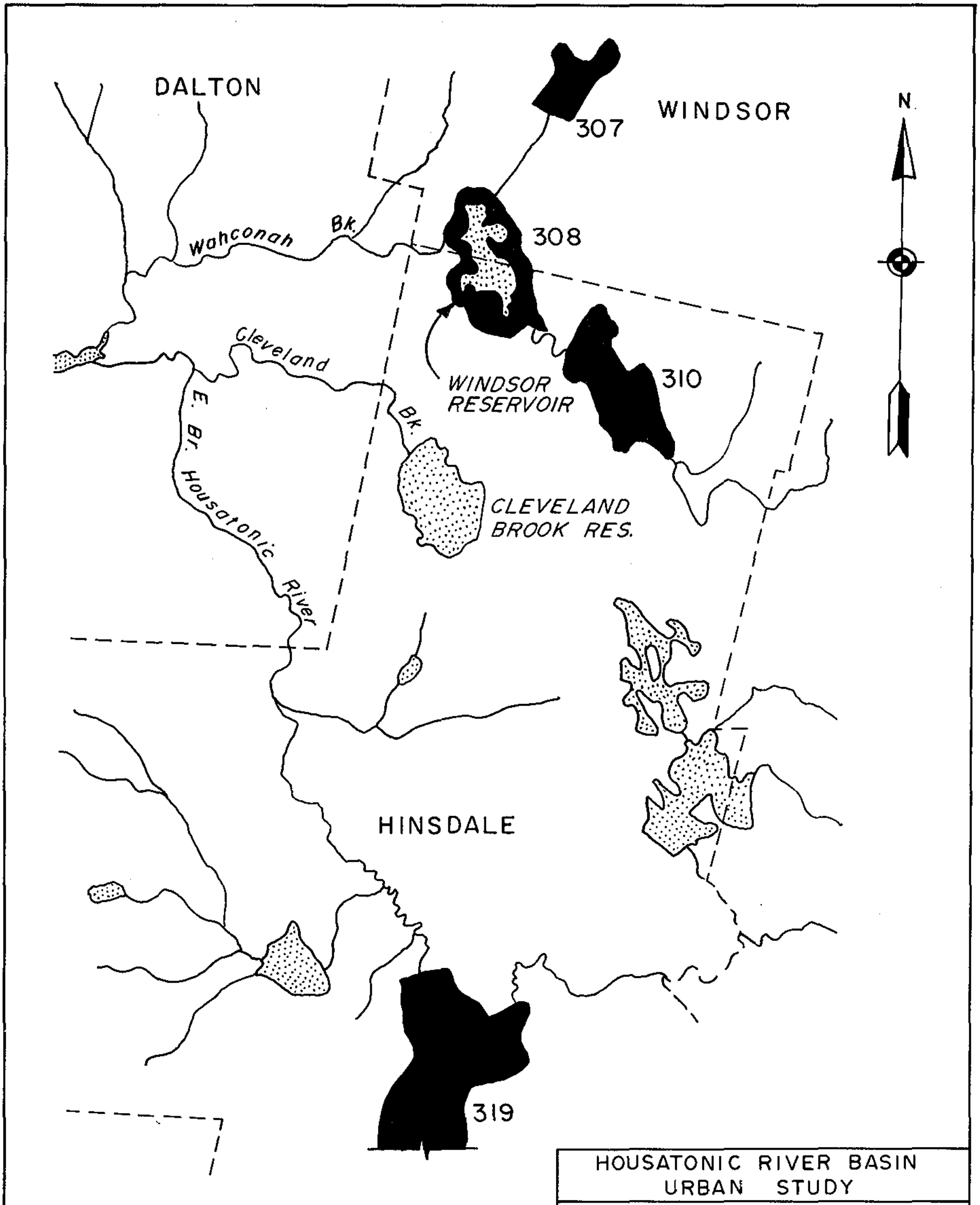
The last site investigated was number 319, located on the East Branch of the Housatonic River. The dam at this site would only have a maximum height of 17 feet and be 2,110 feet long. The size of the inundated area at maximum storage would be about 730 acres. This reservoir could decrease the 100-year stage in Pittsfield by about 18 inches. The total cost of this plan would be about $24 million. When compared with the maximum potential damages that may be prevented this plan also proved not to be feasible.

Other locations for dams were identified in the preliminary stages of this study. But, due to the lack of damages and inadequate storage they were eliminated from further study.

Natural Floodwater Storage Areas

There are a number of natural floodwater storage areas previously identified within the flood-prone areas, such as Hinsdale Swamp, the Brattle Brook area, and the Unkamet Brook area.

Natural storage areas are extremely valuable for retarding flood flows. Their effectiveness depends upon size and location relative to damageable property. The wetlands within the flood plain, depending upon local land values, usually provide the least expensive method of retarding



HOUSATONIC RIVER BASIN
URBAN STUDY

FLOOD CONTROL RESERVOIRS

NOT TO SCALE

floodwaters. For this reason these areas should be retained to provide this temporary retardation of floodwaters and to reduce downstream peak discharges.

In addition to the benefits of flood storage, these areas offer valuable opportunities ranging from recreational to educational. Summaries of some of the environmental resources of three of the most valuable natural floodwater storage areas follow.

Hinsdale Swamp - A good measure of flood protection for Hinsdale Center is provided by Hinsdale Swamp in its present condition. The East Branch Housatonic River slowly meanders through this swamp for a distance of over two miles. The depth of water appears to be adequate for canoeing (see Plate B-18).

The vegetative cover in the flat bottomland area adjacent to the stream consists of speckled alder, arrowwood, willow, and silky dogwood. Bordering this shrub vegetation is a narrow belt of woody vegetation comprised of tamarack, black spruce, and white pine. Adjacent to this narrow belt the vegetation changes to a mixed hardwood-softwood forest with hardwood predominating. Species in this type are quaking aspen, bigtooth aspen, red maple, black cherry, and white pine. The bottomland and adjacent upland cover provide good habitat for a wide variety of wildlife including ruffed grouse, woodcock, whitetail deer, and cottontail rabbit.

Brattle Brook Flood Plain - The large amount of flood storage available in the Brattle Brook reach on the East Branch Housatonic River effectively diminishes the increased flood peaks normally expected from an intensively urbanized area (see Plate B-19).

The flood plain in the vicinity of the confluence of Brattle Brook and the East Branch offers as diversified a habitat for wildlife as could be expected considering its proximity to urban lands. The flood plain adjacent to the confluence is an excellent interspersion of open land, brushy thickets, and woodland. Some of the shrub species observed were speckled alder, silky dogwood, gray stem dogwood, arrowwood, and wild spirea. The most common tree species are red maple and American elm. Wildlife known to inhabit this area includes songbirds such as gold finches, warblers, catbirds, grackles, starlings, robins, bobolinks, red-wing blackbirds, tree swallows, and barn swallows; game birds such as woodcock, ruffed grouse, and pheasant; and other wildlife such as cottontail rabbit, woodchucks, gray squirrels, deer, blacknose dace; however, brown trout have been caught in beaver impoundments in the past. The East Branch through this reach offers a good opportunity for canoeing.

The natural storage areas south of the Brattle Brook confluence are mainly hummocky woodland consisting of red maple, gray birch, American elm, and yellow birch. Understory plants are predominately high bush blueberry and various species of fern. Around the margin of the red maple-elm woodland are dense stands of quaking aspen. (Aspen buds are a prime food source for the ruffed grouse). A power line right-of-way averaging 100 feet in width traverses this storage area. Along this line there are several pockets of cattail and shrubs including arrowwood, elderberry, silky dogwood, golden rod, and various grasses. This has resulted in a woodland-open land "edge" which is of high value to many species of wildlife.

Unkamet Brook Flood Plain -- The environmental resources of the Unkamet Brook wetlands have greatly diminished with the accelerated urban development in the Coltsville area of Pittsfield. Major encroachments in this natural floodwater storage area have occurred. Industrial encroachment along the downstream reach, commercial encroachment in the middle, and residential encroachment and gravel operations in the headwaters have all contributed fill, sediment, debris, and pollutants (see Plate B-19).

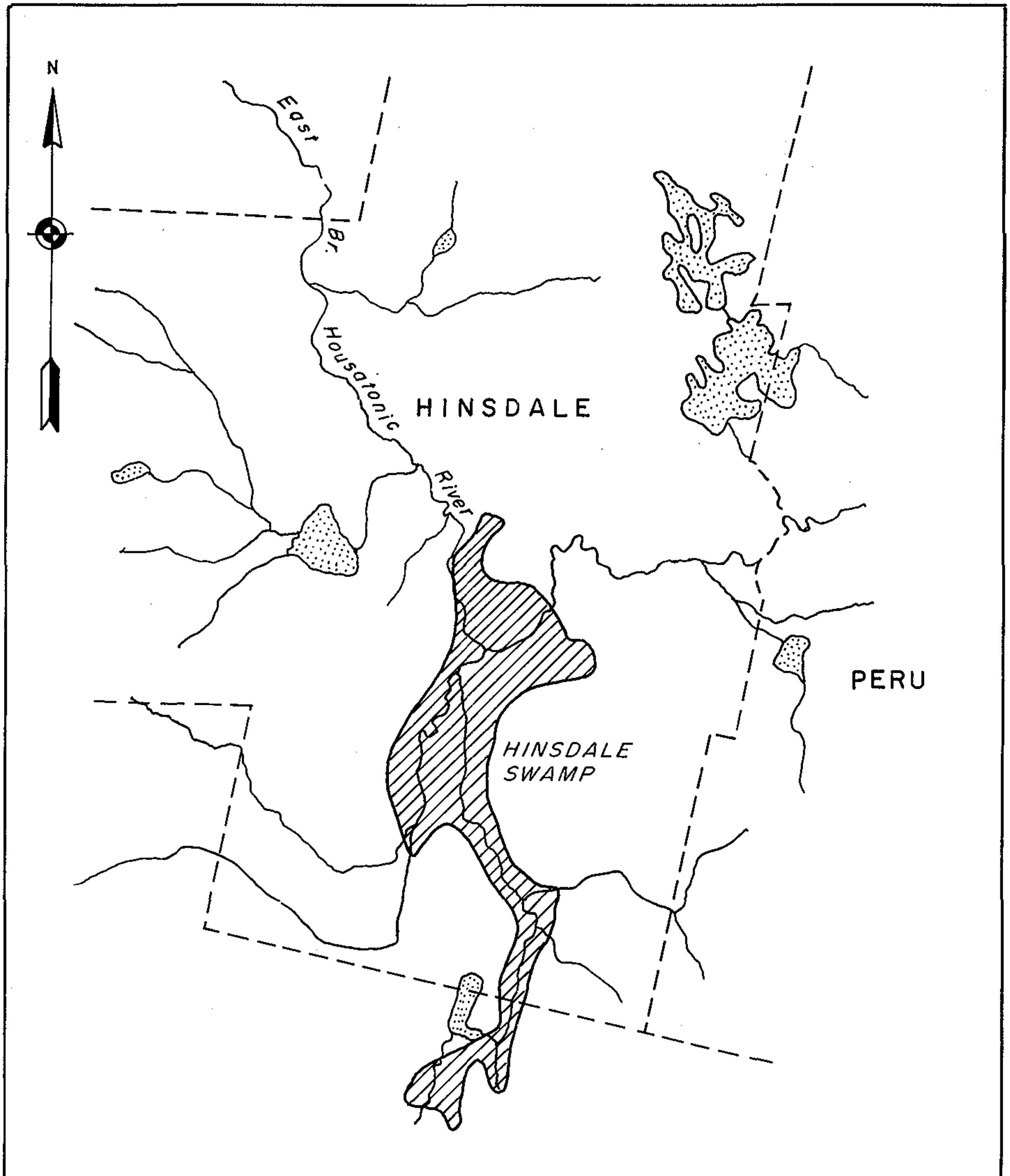
Unkamet Brook has a serious flooding problem, and the problem is two-fold. First, the brook is in a small drainage basin relative to the East Branch and has a lower gradient which results in the basin being lower in elevation. For example, the stream channel bottom of Unkamet Brook at the Dalton Avenue crossing is one foot lower than the stream channel bottom at a point on the East Branch due east of Unkamet Brook. During flood flows on the East Branch it is possible that water backs up Unkamet Brook preventing the brook from entering the East Branch. The second aspect is that stream crossings are all culverts which act as constrictions to flood flows. The stream channel gradient has changed due to siltation, and the structural bottom of the culvert openings do not creat a continuous gradient. Several of the culverts easily collect debris which reduces the flow capacity and increases flood stages. These culverts should be checked frequently and the debris removed.

At present there does not appear to be an obvious solution to the Unkamet Brook backwater problem. However, the natural floodwater storage remaining on Unkamet Brook should be preserved, if possible. The natural wetland above Crane Avenue still offers as diversified a habitat for wildlife as could be expected considering its proximity to urban lands. Loss of this natural storage area will increase the Unkamet Brook flood problem as well as that on the East Branch of the Housatonic River.

Although it is not feasible for the Federal government to obtain these lands to reduce the threat of flooding, it is recommended that local governments in this area control the development of these natural storage areas.

Diversions

Another way to decrease flood flows at critical areas is to divert all or part of such flows around the potential damage site. Flows can be

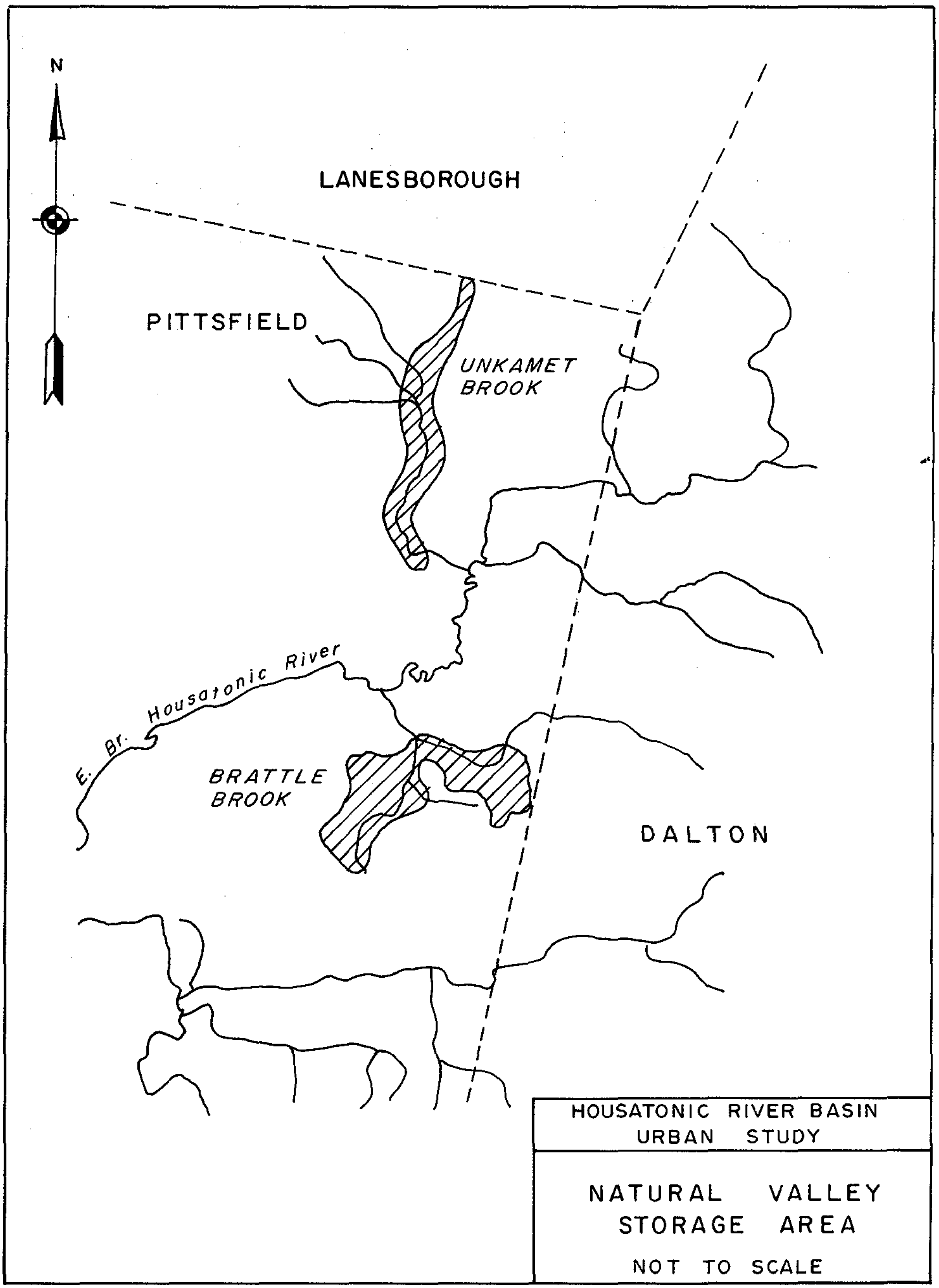


HOUSATONIC RIVER BASIN
URBAN STUDY

NATURAL VALLEY STORAGE AREA

NOT TO SCALE

PLATE B-18



HOUSATONIC RIVER BASIN
URBAN STUDY

NATURAL VALLEY
STORAGE AREA

NOT TO SCALE

PLATE B-19

diverted to other natural channels, man-made channels or conduits. Man-made channels are expensive and potentially unsightly, while closed conduits or tunnels are even more expensive.

The possibility of diverting flood flows around 3 of the major damage areas was evaluated. The areas included Pittsfield, Massachusetts, Danbury and New Milford, Connecticut. The diversion tunnels were designed based on diverting the 100-year flood flows. In all 3 cases the tunnels required would be excessively large and as a result very costly. Diversion tunnels are usually found to be cost effective only in very concentrated, highly urbanized areas, located in small watersheds.

Effects of Channel Improvement

Channel improvement as discussed in this section will relate only to the major hydraulic improvement of a channel by design. Generally, channel work designed as the sole measure to alleviate a flooding problem has a local beneficial effect, but could cause detrimental effects downstream.

For the purpose of this study, it was necessary to assume a design channel for each location selected. In each case, the theoretical channel was proportioned to minimize construction, while enlarging the flow capacity of the existing channel.

The assumption was made that stream crossings presently restricting flood flows would remain unchanged.

The first improvement was located on the East Branch Housatonic River in Pittsfield. The upper portion of the channel improvement was located between East Street upstream (north) to a point opposite the K-Mart. The lower portion of the channel improvement extended from East Street downstream (west) to the natural channel near the footbridge east of Newell Street (see Plate B-20).

The results of this study indicate that flood stages for the 100-year flood could be decreased within the upper reach north of the Penn Central Railroad, but would increase from East Street downstream. Actually, the peak discharges would increase for the 100-year flood by 5 percent at East Street and by 25 percent at the footbridge under this condition. This is a direct result of the accelerated flows created by the new channel and the loss of natural flood storage of Brattle Brook swamp. While reducing the 100-year flood stage by about 1 foot in the vicinity of the Drive-In theater in Coltsville, an increase in flood stage of approximately 3 feet of Lyman Street could be expected. This is not feasible, whereas, higher damages presently occur in the Lyman Street area.

The second area evaluated was located along the Housatonic River in New Milford. The flooding in this area is due primarily to the backwater effect from Lovers Leap Gorge which is very narrow and about one-half mile long. It is not economically or socially feasible to modify the channel through this constricted area.

Removal of Antiquated Dams

There are numerous dams with small impoundments on the branches of the Housatonic River within the study area. Some of these dams are serving the needs of industry, while others are obsolete. At a time when a particular dam no longer serves a meaningful purpose, removal of the structure could be beneficial by reducing flood stages and damages in that locale. Generally, these dams do not significantly retard or store flood water, consequently no adverse effect on discharges or water velocities should be expected. Several dams on the Housatonic River and a few on the upper branches have been removed or breached when deemed of no further use or in need of extensive repairs. This is usually in the best interest of flood plain management. Preliminary investigations indicate it is not feasible to remove any of the antiquated dams in the Housatonic Basin.

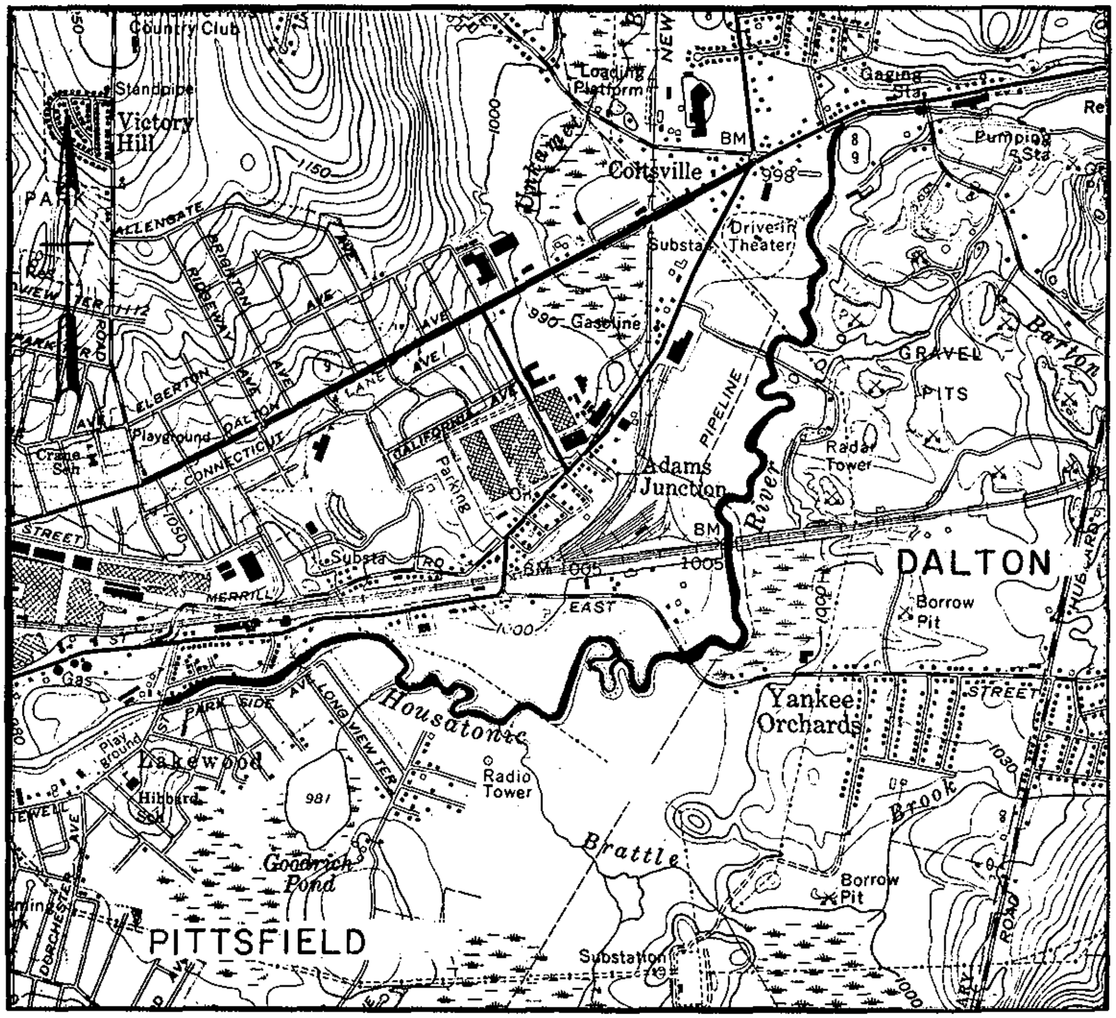
Modification of Bridge Constrictions

There are many bridge crossings along the Housatonic River and its tributaries. If the opening beneath the bridge is undersized it can cause the water during a flood to back up, and raise the flood stage upstream. The bridge crossings that appeared to cause a signficant raise in the flood stage were investigated. It was not found to be economically feasible to remove any of these bridges.

Dikes

Dikes were evaluated to protect many of the major damage areas. The dikes ranged in height from 3 feet in the Coltsville area of Pittsfield to 32 feet in New Milford. The specific damage areas where dikes were studied include:

Elderly Housing around Center Pond in Dalton, MA
K-Mart Plaza in Coltsville Section of Pittsfield, MA
Residential area south of Silver Lake in Pittsfield, MA
Industrial-Commercial area around Silver Lake in Pittsfield, MA
Commercial area along Rte. 20 in Lee, MA
Adams Supermarket Plaza in Lee, MA
New England Log Homes in Gt. Barrington, MA
Commercial-Residential area along Rte 7 in Gt. Barrington, MA
Kent School in Kent, Ct.
Commercial area along Boardman Rd. in New Milford, Ct
Commercial area along Rte 7 in New Milford, Ct.
Industrial-Commercial area around Franklin St. in Danbury, Ct.
Industrial-Commercial area around Eagle Rd. in Danbury, Ct.
Industrial area north of Rte. 108 in Shelton, Ct.
Commercial area along Means Brook in Shelton, Ct.
Residential area along Westbury Park Rd, in Watertown, Ct.



AREA OF CHANNEL IMPROVEMENTS

HOUSATONIC RIVER BASIN
URBAN STUDY

CHANNEL IMPROVEMENTS

None of the dikes evaluated for this section of the report has benefit to cost ratio's over one. These dikes are major structures designed to protect large areas. Smaller walls to protect individual structures or small groups of structures are evaluated in a subsequent section of this report.

DECREASE IMPACT OF FLOODING

Flood Proofing Feasibility

Flood proofing measures can be classified into three broad categories. First, are permanent measures which become an integral part of the structure or land surrounding it. Second, are temporary or standby measures that are used only during floods, but are constructed and made ready prior to any flood threat. Third, are emergency measures that are carried out during flood situations in accordance with a predetermined plan.

The following are five basic flood proofing methods:

1. Rearranging or protecting damageable property within an existing structure.

Some measures in Method 1 can be easily and cheaply implemented by the residential property owner. The rearrangement or raising in place of contents within a structure is eaaily accomplished and can result in significant savings should a flood occur. Utility cells and rooms, while effective flood proofing measures, are expensive and require professional expertise. Because of the expense involved, utility cells and rooms are applicable only to those property owners who experience high flood damages.

The rearrangement or raising in place of contents within a structure is equally applicable to commercial and industrial structures. Cells, elevated rooms or interior floodwalls may be more feasible for commercial/industrial structures because of the generally high cost of repair or replacement of their mechanical equipment.

2. Installing temporary or permanent closures for openings in existing structures.

Structures whose exterior is relatively impermeable to water can be designed to keep floodwaters out by installing watertight closures to openings such as doorways and windows.

Due to buoyant and hydrostatic pressures, closures are not recommended for most residential structures that are not normally designed to withstand such loads.

Generally, closures are better suited to commercial and industrial structures that may be capable of withstanding buoyant and hydrostatic pressures. Permanent masonry closures have been effective in preventing flood damages at many industrial riverine sites in New England.

3. Constructing small wall or dikes around existing structures.

Walls and dikes are effective in preventing damages, but are expensive and require professional assistance. Aesthetics and the amount of surrounding land area, especially in more urban areas, can also create problems for the property owner. Becasue it is a large and expensive undertaking, it is applicable only to those property owners who experience high flood damages. Where flood damages are high, walls and dikes are recommended for commercial and industrial structures, where aesthetics can be less restrictive.

4. Raising existing structures in place.

The cost of raising a structure is the only serious drawback of this measure. Aesthetics and compatability with neighboring homes can be maintained by landscaping or applying adornments such as lattice work, to the area below the first floor. The expense of this method including professional assistance makes it applicable only to those homeowners who experience high flood damages.

Due to size and usage requirements of most commercial and industrial structures, raising may not be physically feasible. The expense of raising a structure, assuming that raising is physically feasible, make it an alternative to be considered only at those sites that experience high flood damages.

5. Relocating existing structures and/or contents out of a flood hazard area.

Both relocation of contents to a new structure and relocation of the entire structure to a new site are costly measures. Only homeowners with high flood damages should consider these measures.

The relocation of the structure to a new site may be physically feasible. Relocation of contents is most applicable at complexes where there may be alternative sites available for the relocation of high value merchandise or machinery.

The analysis of flood proofing alternatives was divided into two distinct categories; residential and commercial-industrial.

Flood proofing alternatives applicable to residences were evaluated on a benefit/cost ratio basis for every home within the detailed study area of the 14 communities. The aggregated results of this analysis is presented in Table 8 of the Main Report. Because both the benefits and costs of residential flood proofing alternatives were derived from curves believed to be representative to typical residences, BCR's of .8 to 1.0 or greater for individual homes were assumed to be potentially feasible flood proofing candidates. The costs of these alternatives were developed from previous Corps studies. (see Appendix C).

Flood proofing alternatives applicable to commercial-industrial structures were evaluated in two ways. For those structures with available damage information an analysis was made comparing relative costs of protection with benefits provided. Physical conditions of the structures were examined for their potential in being incorporated into the flood damage reduction measure. Structures with wood or corrugated metal construction were not considered suitable for closures; therefore walls, earth berms or levees were considered as appropriate measures for these properties. For those structures where closures were considered a 2 foot flooding elevation was considered as a maximum except in those cases where heavier construction techniques were obvious and a 5 foot elevation was used in those cases. The results of the benefit-cost analysis are presented in Table 9 in the Main Report.

For those commercial-industrial structures where damages were not obtained, an evaluation of flood proofing feasibility was made based on: type of construction, depth of flooding and the frequency of flooding. Flood proofing of commercial-industrial structures was assumed to be applicable for those buildings:

1. whose siding material was concrete, concrete block or brick.

2. subject to less than 5 feet of water at the 100-year event.

3. subject to frequent flooding.

A list of individual commercial-industrial structures suitable for flood proofing is presented in Table B-9.

Flood Warning and Evacuation

Flood forecasts, warning and evacuation is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.

- Procedures for issuance and dissemination of a flood warning.

- Arrangements for temporary evacuation of people and property.

- Provisions for installation of temporary protective measures.

- A means to maintain vital services.

- A plan for postflood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process will communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday, weekend) and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain credibility of future warnings.

An effective warning needs to be followed by an effective response. This means prompt and orderly evacuation of people and property. Actions that can facilitate this include:

- Establishment of rescue, medical and fire squads.

- Identification of rescue and emergency equipment.

- Identification of priorities for evacuation.

- Surveillance of evacuation to insure safety and protect property.

The National Weather Service (NWS) was requested to examine the possibility of supplementing their existing system. Based on the flood problems identified in the course of our study, the NWS proposes 3 ALERT forecasts networks which would service principal flood damage areas in the basin. The networks would provide detailed flood forecasts for:

1. Dalton, Pittsfield, Lee and Great Barrington

2. Kent and New Milford

3. Danbury and Brookfield

Flood Plain Regulations

The basic objective of flood plain zoning as a flood damage measure is to minimize future flood damage by limiting the types of activity within the flood plain.

An in-depth review of each community's flood plain zoning regulations was not conducted. It was assumed that communities participating in the National Flood Insurance Program were complying with that program's minimum regulations. Table B-7 presents the status in the program for the 14 communities investigated. Communities in the Regular phase of the program are required to enforce the following restrictions on flood plain development.

TABLE B-7
COMMUNITY STATUS IN
NATIONAL FLOOD INSURANCE PROGRAM(1)

Community	Status in Program	Date of Entry into Program
Dalton	Emergency	18 November 1974
Pittsfield	Regular	1 March 1978
Lee	Emergency	3 October 1974
Kent	Regular	4 March 1980
New Milford	Regular	15 April 1980
Brookfield	Regular	15 June 1979
Danbury	Regular	2 May 1977
Newtown	Regular	15 June 1979
Oxford	Regular	4 December 1979
Seymour	Regular	3 July 1978
Derby	Regular	15 September 1977
Shelton	Regular	29 September 1978
Watertown	Regular	5 November 1980
Torrington	Regular	19 May 1972

(1) as of 31 March 1981, Information Supplied by FEMA

1. All new residences built in the flood plain will be elevated so that the first habitable floor is above the 100-year flood stage.

2. All new commercial and industrial structures will be flood proofed or elevated above the 100-year flood stages.

3. No new construction will be permitted in the floodway unless it can be shown to be compatible with the hydraulic capacity of the floodway.

A key problem with these measures is they only consider flood damages up to the 100-year event. The 100-year elevation criteria of the Flood Insurance Program was adopted by Congress as a minimum standard, but floods of greater magnitudes can occur. For this reason consideration should be given to expanding the flood plain development regulations.

All of the 14 communities have flood insurance studies underway or completed. It is assumed that upon acceptance of finalization of these studies in the near future that all 14 communities will be in the Regular phase of the program and therefore conforming to NFIP minimum regulations.

Flood Insurance

Flood insurance is not really a flood damage prevention measure as it does not reduce damages; rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners.

Flood insurance is an option for all owners of existing buildings in a community identified as flood-prone, yet it is compulsory for all buyers of existing or new buildings in the Federal Emergency Management Agency (FEMA) designated 100-year flood plain where Federally insured mortgages or mortgages through Federally connected banks are involved.

Qualifying for the National Flood Insurance Program involves a community in two separate phases -- the Emergency phase and the Regular phase. The Emergency phase limits the amount of insurance available to local property owners. In this phase, FEMA provides the community with a Flood Hazard Boundary Map that outlines the flood-prone areas within the community.

The full amount of flood insurance is available under the Regular phase of the program. The amounts charged for insurance of new construction vary in accordance with the structures. Flood plain management efforts of the community become more comprehensive and new buildings must be elevated or flood proofed above certain flood levels.

All 14 communities are expected to be in the Regular phase of the program in the near future and therefore property owners will be able to purchase the full amount of flood insurance.

Table B-8 indicates the extent of flood insurance usage in the 14 communities.

Acquisition of Flood Plain Land

Public acquisition of flood plain land is commonly of two types, (1) acquisition of full fee title, (2) acquisition of land use easement. Acquisition in fee is most appropriate for undeveloped land or land with few strucutures or other facilities. With an easement, the ownership, use, access and occupancy may be retained by the owner, but certain uses are restricted.

Based on expected annual damage figures developed, it does not appear that public acquisition of flood plain land and structures would be economically justified.

TABLE B-8
USE OF FLOOD INSURANCE BY COMMUNITY[1]

Community	Number of Residences Insured	Amount of Insurance ($000's)	Number of Commercial/ Industrial Structures Insured	Amount of Insurance ($000's)	Total Amount of Insurance
Dalton	4	$ 112.50	0	$ 0	$ 112.50
Pittsfield	121	3,565.10	14	1,377.90	4,943.00
Lee	10	248.40	0	0	248.40
Kent	6	179.60	1	400.00	579.60
New Milford	61	1,975.00	13	576.00	2,552.10
Brookfield	13	623.20	9	913.30	1,536.50
Danbury	36	1,229.30	75	8,621.40	9,850.70
Newtown	24	1,332.00	6	512.60	1,844.60
Oxford	19	601.20	2	57.00	658.20
Seymour	23	957.60	6	1,228.50	2,186.10
Derby	18	527.80	12	1,071.30	1,599.10
Shelton	65	2,368.60	14	2,191.50	4,366.10
Watertown	34	1,044.10	39	1,242.00	2,286.10
Torrington	37	1,224.00	13	1,588.40	2,812.80

[1] As of 31 May 1981. Information supplied by FEMA.

The following table summarizes the various measures evaluated and which of those were found to be feasible.

Flood Management Measures	Warranted	Criteria Not Met
Adjust Runoff Rate	No	5
Reservoir Management	No	5
New Reservoirs	No	1
Floodwater Storage Areas	No	4
Diversions	No	1
Channel Improvement	No	1
Removal of Dams	No	1, 5
Bridge Modification	No	1, 5
Dikes	No	1, 2
Flood Proofing	Yes	
Flood Warning and Evacuation	Yes	
Flood Plain Regulation	No	4
Flood Inurance	No	4
Acquisition of Flood Plain Land	No	1

1. Economic Feasibility
2. Social Feasibility
3. Technical Feasibility
4. Local Responsibility
5. Ineffective Solution

TABLE B-9
COMMERCIAL-INDUSTRIAL FLOODPROOFING CANDIDATES

		Measure/Level of Protection
Dalton		
1.	Elderly Housing complex	L 500
2.	Byron Weston Mill complex	C 100
3.	Byron Weston Mill complex	C 500
4.	Crane & Co Mill complex	C 500
5.	Crane & Co Mill complex	C 500
Pittsfield		
1.	Ryder Truck	L 100
2.	Berkshire Coating	L 100
3.	Sears Warehouse	C 100
4.	General Electric Plant #5	L 500
5.	Bradlees and Stop & Shop	C or W 500
6.	Petricca Construction	C 500
7.	Burger King	C 500
8.	K-Mart and Price Chopper	C or W 500
9.	Government Mill	C 500
10.	Family Affair	C 100
11.	Webb Plumbing	"
12.	Marchetto Contractor	
13.	Ravin Auto Body	
14.	Italian American Club	
15.	Quality Printing	
16.	Moldmaster Engineering	
17.	Allegrone Construction	
18.	A & P	
19.	Burger Chef	
20.	Berkshire Bank	
21.	Shoppers Halftime	
22.	Greenleaf Autobody	
23.	Pete's Chrysler - Plymouth	
24.	Berkshire Unlimited - Bowling	
25.	Berkshire County Tire	
26.	Kentucky Fried Chicken	
27.	Irus Auto Supply	
28.	Farrell & Gregory	
29.	Mazzo's Importing Market	
30.	Cohen Rubber Stamps	
31.	Francese Building Construction	
32.	Italian Village	"
33.	General Electric Complex @ Silver Lake	C 500
34.	General Electric Navel Sea Systems	C 500
Lee		
1.	Mead Paper - Willow Mill	C 500
2.	Chateau III	C 100

Lee (Cont'd)

3.	Price Chopper	C or W 100
4.	Commercial Plaza left of Adams	C or W 100
5.	Adams Supermarket, Liquors	C or W 100
6.	Commercial Plaza right of Adams	C or W 100
7.	Kimberly Clark	C or W 500
8.	Sunset Motel	L 100
9.	Insul-therm	C or L 100

Kent

1.	Racquet ball-Gym	L 100
2.	Boathouse	C 100
3.	Gymnasium	L 100
4.	Farleigh Dickinson Science Center	C or L 100
5.	North Dormitory	C or L 100
6.	Kent School Art Gallery - Middle Dormitory	L 100
7.	Infirmary	L 100
8.	Dining Hall - Dormitory	L 100
9.	Auditorium	L 100
10.	Administration	L 100
11.	Kent Public School	C 100
12.	Sewage Treatment Facility	L 100

Note: 1 and 3, and 5-10 may lend themselves to common protection measures.

New Milford

1.	J.P. Stevens - 2 buildings	C or W
2.	King's Shopping Plaza	C or W
3.	Nestles - 2 buildings	C or W
4.	Century Brass	C or W
5.	CL&P	C or W

Brookfield

1.	Colonial Shopping Plaza	L 500
2.	Rapid Electric	C 100
3.	Joseph Novicky	C 500
4.	Masters Foods	C 500
5.	Shell	
6.	Sounds Incredible	L 500
7.	Michelin Tire	C or L 100
8.	Record World, The Gap	L or W 500C 500
9.	Woolco	C/L 100/500
10.	Colonial Bank	C or L 100
11.	Roy Rogers	
12.	People's Savings Bank, Alpine Ski	C 500
13.	Friendly Ice Cream	C 500

Note: 5 - 13 may lend themselves to common protection measures.

Danbury

1.	Danbury Dodge	L	500
2.	Bronson Sonic Power	C	500
3.	Family Affair	C	100
4.	Union Trust	L	100
5.	Condec	C	500
6.	Cine Movie Theater	C	100
7.	Stop & Shop	L	500
8.	Goodyear		
9.	Bradlees	L	500
10.	Shopping Plaza		
11.	Shopping Plaza	C	500
12.	Danbury Plumbing	L	500
13.	Bedoukian Research	C	100
14.	GAR Electroforming	C	100
15.	Topstone	L	100
16.	Lostoco Brothers	L	100
17.	Alpha Distributors	C	100
18.	Stetson Warehouse	C	500
19.	Stetson Hats	C	100
20.	Fairfield Processing	C	100
21.	Kingswood	C	100
22.	Monte Carlo Bar	C	100
23.	Danbury Pharmacal	C	500
24.	Stetson Factory Outlet	C	100
25.	Office Building	C	100
26.	New Building	C	100
27.	Commercial Plaza	L	100
28.	New Building	C	100
29.	Industrial Plaza	C	100
30.	Condec	C	500
31.	Condec	C	500
32.	Lee Machine	C	100
33.	Energy Research	C	500
34.	Energy Research Plant	C	500
35.	Furniture & Rug Liquidators	C	500
36.	Concordia Society	C	500
37.	New Times	C	500
38.	Bunker Ramo	W	500
39.	Padanaram Hose Co13	C	500

Note: 4-11, and 12-15 may lend themselves to common protective measures.

Seymour

1.	Rt. 34 Diner	L	100
2.	Arco Station	L	100
3.	Prime Time	L	100
4.	Big John's Drive In	L	100
5.	Tucker Auto Center	L	100

Seymour (Cont'd)

6.	Riverside Pizza	L	100

Note: 1-6 and serveral residences may lend themselves to common protective measures.

Derby

1.	Hull Dye & Print	C	100
2.	Deerfield Meat	C	100

Shelton

1.	Shopping Center	C	100
2.	Derby Savings Bank	C	500
3.	Commercial Building	C	500
4.	Conn National Bank	C	500
5.	Commercial Building	C	500
6.	Commercial Building	C	500
7.	Valley Bank	C	500
8.	Commercial Building	C	500
9.	City Savings Bank	C	500
10.	Commercial Building	C	500
11.	Continental Kitchens	C	500
12.	Shelton Plating	C	500
13.	Better Packages	C	500
14.	Brennan Construction, Apex Tool	C	500
15.	Eastern Chemical	C	500
16.	S & S Plastic	C	500
17.	Stair Co.	C	500
18.	Rolfite	C	500
19.	Chromium Process	C	500
20.	American Specialty	C	500

Watertown

1.	Apt Mfg	W	100
2.	Winchester Electronics	C	500
3.	Timex	C	500
4.	Conn Elect. Sub Station	W	100
5.	Siemon Co.	W	100
6.	Watertown Building Supply - 2 buildings	L	500
2.	Northeast Conn State Office	C	100
3.	John Wilusz Ins.	C	500

Nonstructural Measures

C - Closures
W - Wall
L - Levee

INSTITUTIONAL ANALYSIS

EXISTING INSTITUTIONS

Local Agencies

Water Supply

Municipal Departments. A city or town may create and operate a municipal water department. Most municipal water departments are established by special legislation which defines their service areas, management, structure and powers. A muicipal supply in Massachusetts may not be established in competition with any existing private water utility or a water/fire district. If a municipal water supply is desired, purchase of the private water company presently serving the area is required.

Municipal water departments may be managed by an elected board of water commissioners or by the Board of Selectmen/Mayor through appointed public works officials. Day to day operation is managed by an appointed superintendent.

Municipal water departments are responsible for supply, operation and maintenance of the water system. Departments may make assessments on properties to make system improvements. Bond issues are an option for municipal systems in need of funds for development or renovation projects, although these are usually subject to community approval. Under special enabling acts, communities may, subject to approval of the state, take by eminent domain or acquire by purchase all lands and water necessary to develop and protect water supply sources. Special legislative acts may be required to develop water supply outside the community's boundaries.

Water Districts.

Water districts are public agencies created to provide water supply services to a particular area defined in the legislative agreement establishing the district. Water districts may also be fire districts with the primary purpose of providing fire protection and a secondary function of providing water.

Districts are usually administered by a board of water commissioners and possess the same powers as a municipal water department except with respect to borrowing money.

Water Companies. Unlike municipal systems, private companies do not have recourse to assessing individual properties for liabilities of the company. The private water company's only means of generating revenues is through the sale of water, leasing of hydrants, etc. Water companies are private profit making businesses and must pay taxes on their property holdings.

Water companies are supervised by public utilities agencies, particularly concerning rate structure and franchise territories. Any water company or corporation having franchise rights encompassing an entire city, town or district may, subject to state approval, take by eminent domain or acquire by purchase all waters and lands needed to develop and protect water supply sources.

A summary of the Massachusetts communities within the study area and the primary type of water supply system utilized in each community is shown below. It should be noted that some communities may actually be served by several types of suppliers, but only the major supplier is indicated:

Towns served by municipal systems

Dalton	Lee
Great Barrington	Lenox
Hinsdale	Pittsfield
Lanesborough	Stockbridge

Towns served by private companies

Egremont
Sheffield
West Stockbridge

Towns with no public water supply or limited private systems

NONE	LIMITED
Alford	Monterey
Mount Washington	New Marlborough
Tyringham	Richmond
Washington	
Windsor	

A summary of the Connecticut communities in the study area and the primary type of water supply system utilized in each community is shown below.

Towns served by municipal system or fire districts

Bethel	Middlebury
Canaan	Norwalk
Danbury	Waterbury
Kent	Watertown

Towns served by private companies

Ansonia	Litchfield	Ridgefield	Trumbull
Beacon Falls	Monroe	Salisbury	Weston
Bridgeport	Naugatuck	Seymour	Westport
Cornwall	New Canaan	Shelton	Wilton
Darien	New Milford	Stamford	Woodbury
Derby	Newtown	Stratford	
Easton	Norfolk	Southbury	
Fairfield	North Canaan	Thomaston	
Greenwich	Oxford	Torrington	

Towns with no public water supply or limited, private systems

NONE	Limited, Private Supplies	
Bethlehem	Brookfield	Washington
Bridgewater	New Fairfield	Wolcott
Goshen	Prospect	
Harwinton	Redding	
Morris	Sherman	
Roxbury	Warren	

Local Financing for Water Suppliers

At a local level, public water suppliers may obtain funds for major construction projects by:

General Obligation Bonds - these bonds are backed by the full fiscal resources of the community, including property taxes. Repayment is guaranteed by taxes levied on all real property. These bonds have low interest rates due to their low risk and are easily marketable because of their standardized marketing procedure. An agency must have the power to levy taxes in order to issue general obligation bonds. Issuance usually requires prior approval of the community's voting populace.

Revenue Bonds - repayment of these bonds is through charges levied for services performed by the issuing unit, in this case the water supplier. These bonds are quite popular with revenue agencies for several reasons:

- legal limits don't exist
- the power to tax isn't required
- voter approval isn't required
- they may be used to finance projects extending beyond municipal boundaries.

Although these bonds have higher interest rates, they are usually considered to be on a par with general obligation bonds in terms of risk.

Cash requirements

Revenues enable an agency to meet the cash requirements of operation and maintenance, annual debt service, and repairs. Revenues are usually obtained through service charges, installation charges and general taxation. There are two common methods of billing for services rendered - the wholesale or the retail approach. The wholesale approach, usually used by water systems serving more than one community or district, entails the billing of each individual community or district connected with the system for its share. The retail approach entails the billing of each individual user.

Users are usually billed according to water consumption - with a flat fee charged for a minimum level of water use. Billing practices for use above the minimum level vary among the different suppliers. Some systems charge a constant rate for all units of water used above the minimum level. Other systems employ a decreasing block method-as the water use increases, the cost per unit of water decreases.

All excess revenue from the operation of municipal water departments go to a community's general fund and the funds used by the department come directly out of the general fund. Thus, a water department cannot apply its income towards improvements as private water companies do. Although most municipal water departments prepare their own budgets, the budget must be approved by town meeting members or a city council.

Flood Control

There are usually several agencies within a community that have a concerted interest in flood control. Generally, the agencies discussed below have similar structures and objectives, but there may be some minor differences in a community's or a state's by-laws.

Planning/Zoning Boards

Planning and zoning boards formulate and enforce zoning and subdivision regulations in a community. In larger communities, these boards may be two separate entities. Board members may be elected or appointed, depending upon the community. Usually, the board's jurisdiction encompassess the entire community.

Relative to flood plain management, subdivision regulations may require the installation of proper drainage facilities, identification of flood hazard areas on neighborhood subdivision maps, and restrictions on encroachment into flood plain areas. Zoning may be used to set special standards for land use in flood hazard areas, including specifications for minimum flood elevations.

Connecticut General Statutes, Chapters 124 and 126 define the authority and responsibilities of planning and zoning boards.

Guidelines for planning and zoning boards in Massachusetts are found in Chapters 40 and 40a of the General Laws.

In both states, a board of appeals, appointed by the mayor of a city or the selectmen of a town can hear appeals of zoning or subdivision decisions and make rulings upon them.

Conservation/Wetland Commissions

Local conservation/wetland commissions oversee all significant activities within a community's wetlands and/or flood plains, as well as preserving and acquiring open space, and protecting environment.

Conservation commissions may issue written orders, hold hearing, and set and revoke bond as needed. Violations are punishable by civil remedies as prescribed by State statute, including fines.

Massachusetts General Laws Chapter 131 outline the authority and responsibilities of conservation/wetland commissions. The local commission must be notified of any proposed work to be done in an area deemed significant to water supply or flood control, and may impose conditions to protect such resources.

Conservation commissions in Connecticut have jurisdiction over all regulated activities in designated wetland areas as defined by State statute, sections 22a - 36 through 22a - 45, inclusive. Commissions also act as advisory bodies on environmental and natural resource issues and may acquire land in the name of the municipality. Commission members may be elected or appointed, dependent upon the community.

Building Inspectors

Local building inspectors are responsible for the enforcement of State building codes as well as zoning ordinances and by-laws. Building codes do not restrict land use or development but can reduce flood damage by setting specifications which:

- require anchorage to prevent flotation of buildings.
- establish minimum elevations consistent with potential floods.
- restrict the use of materials which deteriorate in water.

Communities that participate in the National Flood Insurance Program usually are required to have such specifications added to their building codes.

Regional Agencies

Regional Planning Agencies

The principal agency involved with water resources management beyond the community level would be a regional planning agency. These agencies generally provide planning and guidance relating to water pollution control, water supply and flood plain management. Technical assistance to communities with water resources problems would also be provided.

Member communities of a regional agency provide funding on a per capita basis. Additional revenues for operating expenses are obtained through grants from Federal agencies, such as HUD and EPA.

In Connecticut, regional planning agencies are created pursuant to Chapter 127 of the Connecticut General Statutes. Massachusetts General Laws Chapter 40B establish guidelines for regional planning agencies.

State Agencies

Massachusetts

The Water Resources Commission (WRC)

The WRC was created in 1955 to respond to emergency flood conditions and to comply with the requirements of PL 566 for small watershed protection. Major duties of the WRC include:

- studying the needs, supplies and resources of the State with respect to water conservation and flood prevention.

- responsibility for the programs provided for by the Watershed Protection and Flood Prevention Act.

- responsibility for any works of improvements, including any undertaking for flood prevention.

Department of Environmental Quality Engineering (DEQE)

The Department of Environmental Quality Engineering is an agency of the Executive Office of Environmental Affairs. Among DEQE's major responsibilities in water resource management are:

- administration of the wetlands regulatory program

- approval of new water supplies

- issuance of rules and regulations for the protection of water supplies

• management and coordination of planning activities

• development of comprehensive plans for growth and development

Department of Environmental Management

The Department of Environmental Management's major responsibilities for water resources are:

• coordination of water and related land resources activities of State, interstate, and Federal agencies as they affect Massachusetts

• guiding the formulation of all water resource policy and law not relating to water quality.

• comprehensive river basin and water use area planning through special studies and coordination of review of all A-95 projects and environmental impact statements related to water resource projects.

• participation in water resources development, and management programs.

Department of Public Works (DPW); Division of Waterways

The DPW has the authority over great ponds (all ponds over 10 acres in area).

Public Utilities Department

The Public Utilities Department's major responsibilities for water supply are to hold hearings and make decisions on requests for rate changes. All private water utilities must also file annual reports with the department on their rates, number of customers served and number of metered customers.

The Massachusetts General Court

The Massachusetts General Court exerts significant influence over water supply activities as all local water supply agencies must seek legislative approval for development outside of local jurisdiction and for diversion out of watersheds.

Department of Public Health

The Department of Public Health has the power to approve the quality and adequacy of water supply sources and treatment works, as well as to set water quality standards.

Connecticut

Department of Environmental Protection

The Department of Environmental Protection (DEP) has wide ranging jurisdiction encompassing protection, regulation and management of air, land and water resources in Connecticut. Major activities of DEP with regard to water resources include:

- long range water management planning
- water pollution control
- sales of excess water permits
- watershed flood management projects
- tidal and inland wetlands permits

Department of Health Services (DOHS)

The Department of Health Services has the power to approve the quality and adequacy of water supply sources and treatment works and set water quality standards.

Department of Public Utility Control (DPUC)

The Department is responsible for regulating all privately-owned water supply systems serving 50 or more customers (with the exception of homeowners or condominium associations). The agency controls the rates that are charged for water by private water companies as well as their engineering, accounting, service and operational functions, including extension of mains, acquisition of other water companies, sale of assets and issuance of stocks and bonds. Its authority involving municipally-owned water systems does not include setting of rates; and, it is limited to only requiring those utilities to maintain their records in accordance with a uniform System of Accounts and to furnish, along with the investor-owned companies, a statutory Annual Report submission; and as a final adjudicating authority involving termination of customers service.

Connecticut General Assembly

The General Assembly reviews all requests for development of water supplies outside of local jurisdiction and for diversion out of watersheds.

Federal Agencies

U.S. Army Corps of Engineers

Part of the Department of Defense, the Corps of Engineers is involved in various aspects of water resources planning and development.

The Water Supply Act of 1958 (Title III of PL 85-500) authorized the Corps to provide storage capacity for municipal and industrial water supply in reservoirs primarily for other purposes, on the condition that non-Federal interests agree to pay the cost allocable to such storage.

Section 206 of the 1960 Flood Control Act, as amended, authorizes the Corps to provide information, technical planning assistance and guidance upon request to Federal, State, and local agencies as well as individual citizens, in identifying flood hazards and encouraging the prudent use of flood plains.

In addition to Congressionally authorized flood control projects such as the construction of dams and reservoirs, the Corps also has special continuing authorities to provide funds for small flood control works.

Federal Emergency Management Agency

The Federal Emergency Management Agency administers programs for disaster planning and recovery, as well as providing technical assistance to States and communities to encourage wise flood plain use. The Federal Insurance Administration (FIA), a division of FEMA, administers the National Flood Insurance Program (NFIP). A breakdown of the communities in the study area that are participants in the Emergency or the Regular phase of the NFIP follows:

REGULAR PROGRAM

Connecticut

Beacon Falls	Middlebury	Southbury
Bridgeport	Naugatuck	Stamford
Bridgewater	New Canaan	Stratford
Brookfield	New Milford	Torrington
Danbury	Newtown	Trumbull
Darien	Norwalk	Waterbury
Derby	Oxford	Watertown
Fairfield	Prospect	Weston
Greenwich	Seymour	Westport
Kent	Shelton	Woodbury

Massachusetts

Alford
Pittsfield

EMERGENCY PROGRAM

Connecticut

Ansonia	Litchfield	Roxbury
Bethel	Monroe	Salisbury
Bethlehem	Morris	Sherman
Canaan	New Fairfield	Thomaston
Cornwall	Norfolk	Warren
Easton	North Canaan	Wilton
Goshen	Redding	Wolcott
Harwinton	Ridgefield	

Massachusetts

Dalton	New Marlborough
Egremont	Richmond
Great Barrington	Sheffield
Hinsdale	Stockbridge
Lanesborough	Washington
Lee	West Stockbridge
Lenox	
Monterey	

Soil Conservation Service

The Soil Conservation Service of the Department of Agriculture is a technical agency created to develop and carry out a national soil and water conservation program. Among other services, SCS provides technical assistance to local governments in implementing flood plain management programs as well as assistance to dealing with the conservation and development of land and water resources. This assistance is provided primarily under three authorities: 1) the Soil Conservation Act of 1935, 2) the Flood Control Act of 1944, and 3) the Watershed Protection and Flood Prevention Act of 1954, Public Law 566.

Water Resources Council

The Water Resources Council was established by the Water Resources Planning Act of 1965 to encourage conservation, development and utilization of water and related land resources on a comprehensive coordinated basis.

U.S. Environmental Protection Agency (EPA)

Under provisions of the Safe Drinking Water Act of 1974, the U.S. Environmental Protection Agency has the primary responsibility for establishing and enforcing drinking water standards and otherwise supervising public water supply systems and sources of drinking water. Interim primary drinking water standards have been established by EPA and became effective 24 June 1977.

It is the intent of the Act to transfer the EPA's enforcement responsibilities for protecting drinking water to the States. To assume this responsibility, States must have drinking water regulations no less stringent than the Federal regulations as presribed in the Act and should have a plan for providing safe drinking water in emergency situations. They must also have monitoring programs that comply with Federal requirements and sufficient enforcement authority.

EPA has been working with the States to assist them in the development of laws and regulations necessary to carry out their enforcement responsibilities. Whenever a State does not force a public water system's compliance with drinking water regulations or a schedule imposed with a variance or exemption, EPA is directed to begin enforcement action.

Other Federal Agencies

The National Weather Service, the U.S. Geological Survey, the Farmer's Home Administration and the Economic Development Administration administer programs which provide assistance to communities in water supply development and/or flood plain management.

EXISTING LEGAL FRAMEWORK

Water Rights

In both Connecticut and Massachusetts, the rights of each community are defined by special acts of the State Legislature. Since communities are chartered by the State, their rights are subject to the State's authority. This means the State can pre-empt rights to various water bodies (including groundwater) or give one community authority over a body of water lying in another community. The water body may not be jointly used by another water supplier without the permission of the first user.

Apart from water rights granted by special acts, water rights in both States are determined by the doctrine of "riparian rights of reasonable use" by which a landowner is entitled to make reasonable use of water flowing on his land or contiguous to it. This doctrine is a common law one which has evolved over time through judicial decisions.

Protection of Water Supply

Municipalities have the power to take, by eminent domain, all lands and water necessary to develop and protect water supply sources. In addition, municipalities have the power to issue protective orders to restrict alterations of wetlands which are significant to water supply, as well as the authority to use zoning to protect areas important to water supply.

The State has the authority to take action to preserve the quality of water used as sources of public supply.

Flood Control

The management of flood plains is primarily a function of local government. However, local flood hazard mitigation regulations must be in conformance with both State and Federal flood management regulations. State and Federal agencies, as mentioned, have a substantial interest in flood control and have many programs available to assist local governments in minimizing flood loss potentials.

INSTITUTIONAL ALTERNATIVES

Water Supply

The purpose of this section is to outline a general alternative institutional framework to which refinements can be made after water supply alternatives have been formulated. Combinations of various alternatives may be required to fully address the area's needs.

Local Options

Public and private water utilities could continue to supply water on a local basis. Individual communities or supply systems would be responsible for the planning, financing, construction and operation of their own facilities in conjunction with each State's laws, regulations and institutional arrangements.

Regional Options

A regional district could be established by a special State legislative act. Membership can be either optional or mandatory. Generally, the regional supplier is responsible for the development, operation and maintenance of the water supply source and related facilities, while the community or districts supplied are responsible for the distribution to the individual consumer. A commission set up to oversee the water district generally consists of commissioners appointed on the basis of population served in each municipality.

State Options

One or more agencies responsible for providing water supply services on a statewide basis could be established. Planning, financing and construction activities would be carried out at the State level. District level offices would be responsible for day to day operation, maintenance and monitoring functions for the water supply system under their jurisdiction.

State agencies, separate from the water supply agency(s), would be responsible for establishment and enforcement of rules and regulations for system operation.

Interstate Options

In areas such as the Housatonic River Basin, where the basin encompasses more than one State, a river basin commission responsible for water supply management could be established. Establishment of such a commission would require special legislation by participating States as well as interstate agreements. Administration would be the responsibility of a board of commissioners, whose members are appointed by the governor of each State. Existing local water supply agencies would continue to operate as usual, but new projects would be subject to review and approval by the commission. The commission would also have the authority to set rates for water use and bill water users.

Federal Options

Historically, Federal involvement in water supply management has been limited. The Water Supply Act of 1958 stated that the policy of the Federal government is to recognize the primary responsibility of State and local interests in the development of water supply and that the federal government should cooperate with States and local interests in the development of water supply in connection with Federal navigation, flood control, irrigation and multi-purpose projects. The Rivers and Harbors Act of 1965 places greater emphasis on a direct Federal role in planning and possibly construction and management of water supply systems. However, the feasibility of Federal takeover of water supply and distribution functions is quite low due to the heterogeneity of sources, requirements, existing institutions and local preference for home role.

Future options for Federal participation in water supply management consist of limited direct roles or indirect, stimulatory, roles. Direct participation would basically be Federal provision of water supply facilities to supplement existing systems. Indirect options would include stronger Federal programs to provide funds and technical assistance for State and local planning.

Flood Control

Alternatives

There appears to be two categories of flood control alternatives that would be feasible to implement. These are: flood plain management measures and nonstructural flood control measures.

Flood Plain Management Measures

These measures attempt to modify flood damage susceptibility by restricting the type and extent of development that will take place in the flood plain. Generally, these measures are in the form of land use regulations, but they may also take the form of building codes or a design and location of utilities policy.

Nonstructural Flood Control Measures

These measures attempt to minimize flood losses to existing development. Some typical measures include: increased participation in the National Flood Insurance Program, floodproofing structures, and implementation of a flood warning and evacuation plan.

Levels of Government Involved

Local

The community has the primary responsibility of recognizing its implicit flood hazards and taking steps to minimize both the hazards and the resultant losses. Some alternatives can be implemented directly by the community (*i.e., increased regulations*).

A community may request assistance from a Federal agency in identifying its potential flood hazards and/or alternatives to modify potential flood losses. If any flood hazard mitigation measures are determined to be feasible, the community may contract with the Federal agency to implement the measures on a cost-sharing basis with the bulk of the cost assumed by the Federal entity.

In Connecticut, only the Department of Environmental Protection and a qualified municipal Flood and Erosion Control Board may enter into an agreement with a Federal agency for flood control works.

State

It is at this level that standards and procedures are set to serve as guidelines. Multijurisdictional problems not manageable at the local level can usually be resolved at the State level. A statewide coordinating office to encourage flood plain management in local planning and to maintain liaison with Federal agencies would be the optimal State role.

Federal

The Federal role is basically a strong supportive one gathering information developing flood plain management techniques, funding programs and providing technical, planning and construction services.

APPENDIX C

TECHNICAL APPENDIX

TECHNICAL APPENDIX

LIST OF TABLES

LIST OF PLATES

INTRODUCTION

This appendix presents the hydrologic, design and cost analysis pertinent to the Stage II flood control and water supply studies of the Housatonic River. Included are sections on watershed description, climatology, analysis of floods, droughts and groundwater.

WATERSHED DESCRIPTION

General. The Housatonic River and its tributaries drain an area of 1,949 square miles in the western portions of Connecticut and Massachusetts and eastern New York. The basin, shown on Plate C-1, is roughly elliptical in shape, oriented in a north-south direction with a maximum length and width of 98 and 35 miles, respectively. It is a hilly basin with forested uplands and cleared valleys. Elevations vary from the National Geodetic Vertical Datum (NGVD) to 2,620 feet NGVD along the northern divide. There are numerous lakes and ponds scattered throughout the basin that have a modifying influence on minor floods, but generally have little effect on major floods. There is considerable valley storage on the main stem between Great Barrington and Falls Village, which has a significant effect in desynchronizing floodflows from the upper watershed.

The Housatonic River rises near Washington Station, Massachusetts in the Berkshire Hills and flows in a southerly direction for 146 miles through Massachusetts and Connecticut to its mouth in Stratford on Long Island Sound. In the headwaters above Great Barrington, Massachusetts the valley is narrow and the river is steep as it emerges from the Berkshire Hills. Between Great Barrington and Falls Village, Connecticut, the river meanders through a generally broad valley varying from 1 to 3 miles in width. The river valley from Falls Village to tidewater at Shelton Dam is generally narrow and flanked by hills on either side. In the lower 12 miles from Shelton to Stratford the river is a tidal estuary and has been improved for navigation. The mainstem of the Housatonic River has an overall fall of about 960 feet and an average slope of 7.3 feet per mile. The more important tributaries of the Housatonic River in downstream order are: East and West Branches, Ten Mile, Still, Shepaug, Pomperaug, and Naugatuck Rivers.

Tributaries

Naugatuck River. The Naugatuck River is the largest and most important watershed of the Housatonic River. The general flow is southerly through Torrington, Thomaston, Waterbury, Naugatuck, Beacon Falls, Seymour, and Ansonia to Derby where it discharges into the Housatonic River, 12 miles above its mouth. The watershed of the Naugatuck River is located primarily within the boundaries of Litchfield and New Haven Counties, with a small portion extending into Hartford County. The Naugatuck River watershed has a maximum length and width of approximately 50 and 12 miles, respectively, and a drainage area of 312 square miles. It has a rather uniform slope of about 14 feet per mile between the headwaters at Torrrington and tidewater in Derby, Connecticut. The river valley is narrow with rocky hills rising on either side of the river. Elevations vary from a maximum of 1,625 feet NGVD on Dennis Hill in Norfolk along the northern divide to approximately 5 feet at the mouth. Its several relatively short and steep tributaries are conducive to rapid runoff. Major tributaries are the East and West Branches, Leadmine Brook, Branch Brook, Hancock Brook, Mad River, Meadow Brook, Little River, Bladdens River and Beaver Brook.

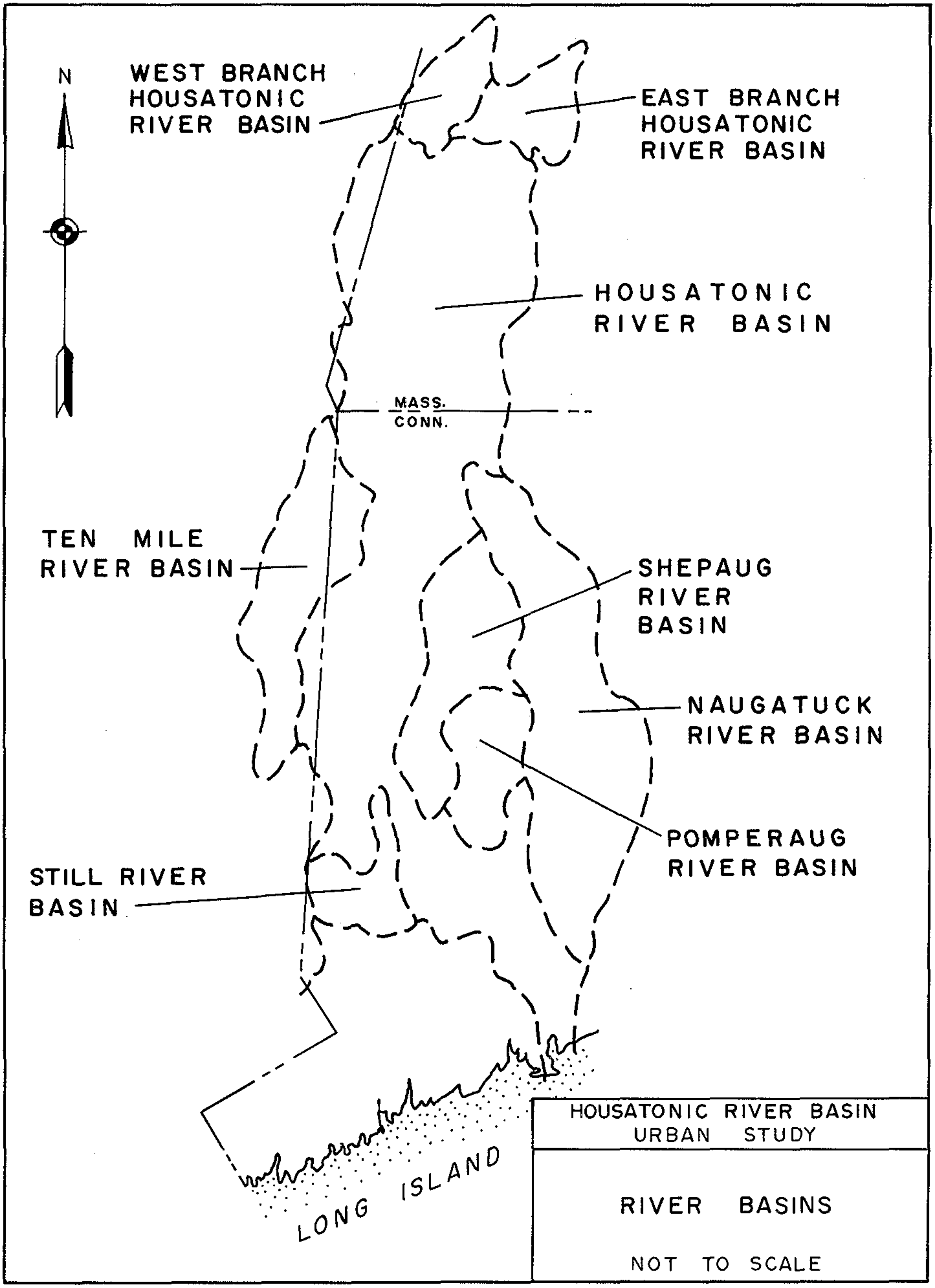
East Branch - Housatonic River. The East and West Branches of the Housatonic River unite in the vicinity of Pittsfield, Massachusetts to form the mainstem of the Housatonic River. The East Branch rises in Muddy Pond near Washington Station, and flows in a northerly direction through Hinsdale to Dalton, then in a general southwesterly direction to its junction with the West Branch, a total distance of approximately 17 miles. This tributary has a drainage area of 71 square miles and a total fall of about 480 feet.

West Branch - Housatonic River. The West Branch has its source in Pontoosuc Lake in the northern part of Pittsfield. The river follows a southerly course for about 5 miles to its confluence with the East Branch. This branch drains an area of 59 square miles, and falls 140 feet in its 5-mile course below Pontoosuc Lake.

Ten Mile River. The drainage area of Ten Mile River is 210 square miles, most of which lies in Dutchess County, New York. It joins the Housatonic River at mile 52, three-quarters of a mile below Bulls Bridge, Connecticut. The river has an average slope of about 4.3 feet per mile over its 35 mile length. The extensive valley storage coupled with the mild streambed slope, results in a moderate watershed runoff characteristic. It has been considered as a possible source of water supply for New York City, but to date its interstate character has precluded its development for this purpose. Principal tributaries are the Swamp River and Webatuck and Wassaic Creeks.

Still River. The Still River has an area of 71.5 square miles and enters the Housatonic River at mile 40.6, about 2 miles downstream of New Milford, Connecticut. The headwater topography is hilly and the river has a slope of nearly 20 feet per mile for about 8 miles; however, the lower 11 miles below the Danbury-Brookfield town line has a comparatively flat gradient and narrow watershed. The river has a total length of 21.9 miles and falls 260 feet between its source in Lake Kenosia and the Housatonic River. There are numerous lakes above Danbury which are utilized for municipal water supply. Principal tributaries of the Still River are the Sympaug, Padanaram, Blind and Limekiln Brooks.

Shepaug River. The Shepaug River has a long, narrow drainage area of 156 square miles lying wholly within the State of Connecticut. It has an average slope of about 30 feet per mile over its 37.5 mile length. The source of the Shepaug River is west of north Goshen, from whence it flows


N
WEST BRANCH
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CONN.
TEN MILE
RIVER BASIN
SHEPAUG
RIVER
BASIN
NAUGATUCK
RIVER BASIN
POMPERAUG
RIVER BASIN
STILL RIVER
BASIN
LONG ISLAND
HOUSATONIC RIVER BASIN
URBAN STUDY
RIVER BASINS
NOT TO SCALE

PLATE C-1

in a southerly direction joining the Housatonic River about 10.5 miles below New Milford, Connecticut. The lower 3.5 miles are within Lake Lillinonah, formed by the Shepaug Dam on the Housatonic River at mile 30. About 25 miles above its mouth, the city of Waterbury has constructed a water supply reservoir and at times, diverts practically the entire runoff from the 38 square mile drainage area of the West Branch of the Shepaug River above the dam. The only important tributary of the Shepaug River is the Bantam River.

Pomperaug River. The Pomperaug River drains an area of 88.8 square miles in Connecticut between the Shepaug and Naugatuck Rivers. The average slope over the 22.7 mile length is about 7 feet per mile. Principal tributaries of the Pomperaug River are the Weekeepeemee and Nonewaug Rivers.

Non-Federal Reservoirs

General. There are a significant number of non-Federal reservoirs or lake systems in the basin which are used for power, water supply or recreation purposes. Although none of these reservoirs has storage set aside for flood control purposes, it is recognized that several of the power and water supply reservoirs are drawn down during the winter months and are capable of storing the runoff during the spring snowmelt periods. The power dams are generally operated for peaking purposes, although during the springtime, and at other times when riverflows are considerable, some dams generate power continuously. Pertinent information on 19 selected projects are briefly summarized in Table C-1. The three largest reservoirs are further described in the following paragraphs.

Candlewood Lake. Candlewood Lake Dam is located near the mouth of the Rocky River about two miles west of New Milford, Connecticut. The lake itself extends into Brookfield, New Fairfield and Danbury and has a drainage area of 32 square miles on Rocky River. This pumped storage project is operated by the Connecticut Light & Power Company, with water pumped from the Housatonic River at the Rocky River power house during non-peak power periods. It has a total storage of 172,000 acre-feet and usable storage of 142,600 acre-feet. The Rocky River drainage basin contributes little if any to peak flows in the Housatonic River.

Lake Lillinonah. Lake Lillinonah, located in Newtown, Brookfield, New Milford and Bridgewater, Connecticut is formed by the 147-foot high Shepaug Dam. The dam, located 2.3 miles north of the center of Newtown at river mile 30, has a drainage area of 1,392 square miles and is used for hydroelectric power by the Connecticut Light & Power Company. The usable storage of approximately 5,400 acre-feet has no dependable beneficial effect upon floodflows in the Housatonic River (total storage is 74,000 acre-feet). In the past some of the storage evacuated in anticipation of a flood to minimize the backwater effect of the lake in the New Milford area has affected flood levels downstream. The project design discharge capacity is 132,400 cfs, of which 126,700 are passed over the spillway and remainder through the station.

TABLE C-1

PERTINENT DATA
SELECTED NON-FEDERAL RESERVOIRS (1)

Project	River	Drainage Area (sq.mi.)	Owner	Total Storage (ac/ft)	Purpose
Pontoosuc Lake	West Br. Housatonic	24.2	Berkshire County, MA	5,000	R
Onota Lake	Onota Brook	10.3	City of Pittsfield, MA	5,130	R
Cleveland Res.	Cleveland Brook	1.4	City of Pittsfield, MA	5,680	WS
Center Pond	East Br. Housatonic	53.8	City of Dalton, MA	370	R
Shaker Mill Pond	Williams	33.0	Town of Stockbridge, MA	500	R,C
Mill Pond	Hubbard Brook	26.8	Private	605	R
Rising Paper Co. Dam	Housatonic	333.0	Rising Paper Co.	215	WS
Great Falls Dam	Housatonic	631.0	Conn. Light & Power	450	P
Bulls Bridge Dam	Housatonic	781.0	Conn. Light & Power	1,320	P
West Twin Lake	Schenob Brook	7.3	Private	9,146	R
Woodbridge Lake	Marshepaug	8.9	Private	6,630	R
Upper Shepaug Res.	West Br. Shepaug	10.5	City of Waterbury, CT	10,250	WS
Shepaug Res.	Shepaug	38.0	City of Waterbury, CT	4,090	WS
Wigwam Res.	Branch Brook	17.5	City of Waterbury, CT	4,100	WS
Candlewood Lake	(3)	40.5	Conn. Light & Power	172,000	P,R
Trapp Falls Res.	Pumpkin Ground Brook	1.1	Bridgeport Hydrolic	7,280	P
Shepaug Dam	Housatonic	1,391.0	Conn. Light & Power	74,000	P,R
Stevenson Dam	Housatonic	1,545.0	Conn. Light & Power	26,900	P,R
Derby Dam	Housatonic	1,580.0	United Illuminating Co.	4,428	P,R

(1) Drainage area greater than 20 square miles OR storage greater than 4,000 Acre-Feet
(2) R - Recreation; WS - Water Supply; C - Conservation Storage; P - Hydroelectric Power
(3) Pump Storage facility

Lake Zoar. Lake Zoar provides storage for hydroelectric power generation at the 124-foot high Stevenson Dam on the Housatonic River at mile 19.2. It has a usable pondage capacity of approximately 5,040 acre-feet, a total capacity of 26,900 acre-feet and a drainage area of 1,545 square miles. This project is an element in the Connecticut Light & Power Company system and is operated similar to the Shepaug project 10 miles upstream. Its limited storage has negligible effect upon floodflows in the lower Housatonic River. The design discharge capacity is 119,000 cfs, 113,000 over the spillway and 6,000 through the station.

Federal Reservoirs

Flood Damage Reduction Measures - The Corps of Engineers has completed seven flood control dams and reservoirs in the Naugatuck River basin which help to reduce floodflows on the Naugatuck River (see Plate C-2). The Corps has also completed two local protection projects downstream of Thomaston Dam which protect specific areas from flooding. A brief description of each dam follows:

Hall Meadow Brook Dam

Hall Meadow Brook Dam is located on Hall Meadow Brook, about 0.4 mile above its confluence with Hart Brook, where the two join to form the West Branch of the Naugatuck River about 5 miles above the city of Torrington.

Construction of the dam was started in 1961 and completed in June 1962 at a cost of $3,131,000 of which $570,000 were non-Federal funds. Upon completion, the project was transferred to the State of Connecticut for operation and maintenance.

In conjunction with the East Branch Reservoir and the two local protection projects in Torrington, the project provides flood protection to the upper Naugatuck Valley communities of Torrington, Harwinton, and Litchfield. In a recurrence of the August 1955 flood, the flood of record in the Naugatuck Valley, the project would prevent about $29.0 million in damages.

East Branch Dam

East Branch Dam is located on the East Branch of the Naugatuck River, within the Torrington city limits, about 2.5 miles upstream of the center of the city. Construction of the dam was started in 1963 and completed in June 1964 at a cost of $1.9 million in Federal funds and $840,000 in State funds. Following completion, the project was transferred to the State of Connecticut for operation and maintenance. The reservoir forms part of the comprehensive plan of flood protection in the Naugatuck Valley and contributes to flood stage reductions at Torrington and downstream damage centers. In a recurrence of the 1955 flood, the project would prevent about $10,510,000 in damages.

Thomaston Dam

Thomaston Dam is located on the Naugatuck River about 1.6 miles north of the town of Thomaston and about 6 miles upstream of the city of Waterbury. The project was completed for flood control and provides flood protection for public and private facilities below the dam in the highly industrialized and densely populated Naugatuck Valley. Major reductions in flood damages are effected at Thomaston, Waterbury, Naugatuck, Beacon Falls, Seymour, Ansonia, and Derby. In a recurrence of the August 1955 flood, the project would prevent about $253.1 million in damages. The State Park and Forest Commission leases the reservoir area. The Corps of Engineers operates and manages the vista and picnic areas in the vicinity of the dam.

Northfield Brook Lake

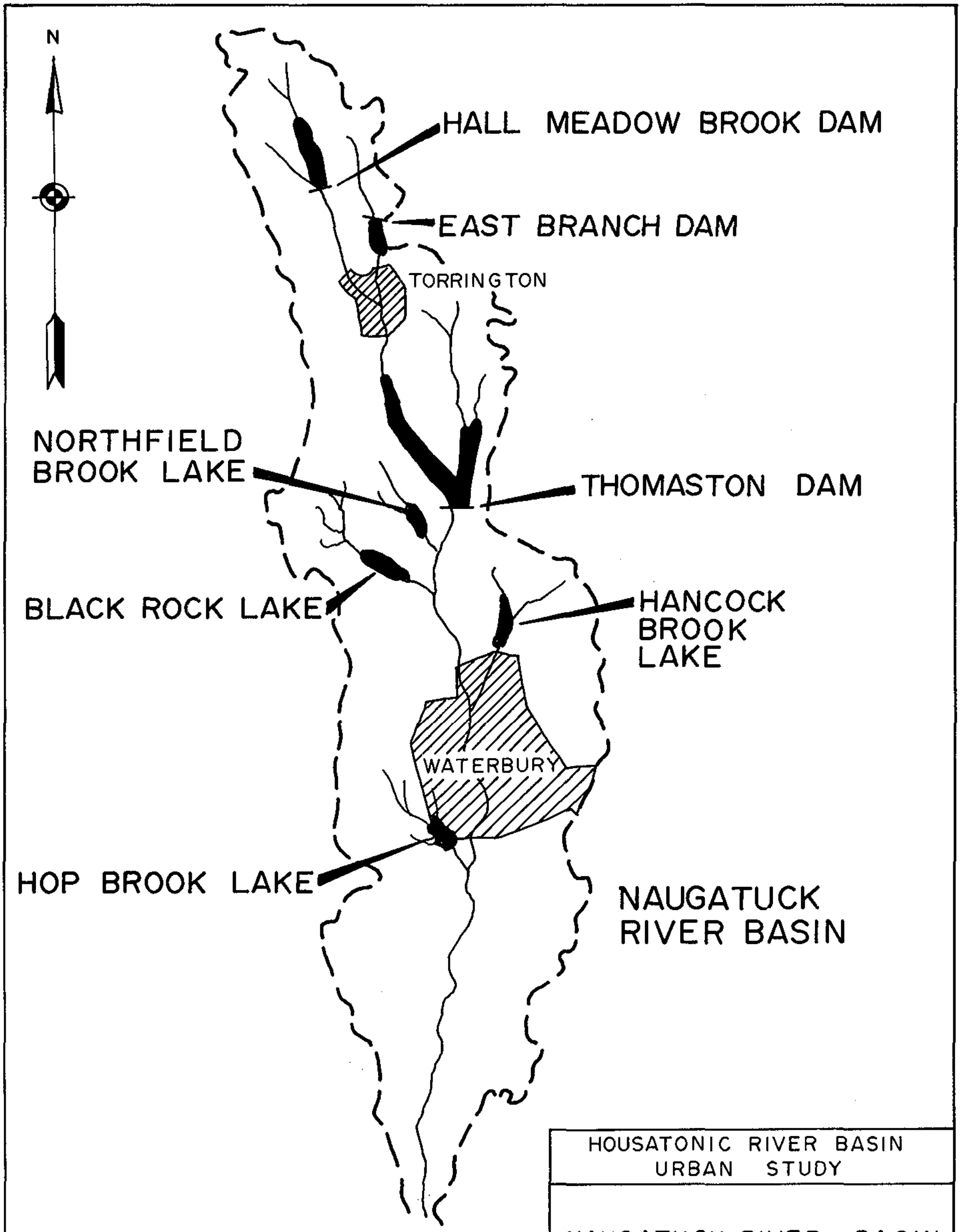
Northfield Brook Dam is located on Northfield Brook in the town of Thomaston, about 1.3 miles upstream of the mouth of Northfield Brook and 7 miles north-northwest of the city of Waterbury. Construction of the dam and appurtenances was initiated in 1963 and completed in October 1965. The project cost was $2,831,000. As part of the comprehensive plan for flood control in the Naugatuck Valley, the reservoir aids in reducing floodflows in the downstream communities along the Naugatuck River. In a recurrence of the August 1955 flood, it would prevent $5.3 million in damages.

Black Rock Lake

Black Rock Dam is located on Branch Brook, along the Thomaston-Watertown line in Black Rock State Park. Construction was initiated in 1966 and completed in July 1970 at a Federal Cost of $8,210,000. The project is an integral unit in the authorized plan for control of floodflows along the Naugatuck River. Operation of the project is coordinated with the operation of Thomaston Dam in times of anticipated flooding downstream. In a recurrence of the August 1955 flood it would prevent $14.6 million in damages.

Hancock Brook Lake

Hancock Brook Dam is located on Hancock Brook, about 3.4 miles above its confluence with the Naugatuck River in the town of Plymouth. Construction was started in 1963 and completed in September 1966 at a cost of $4,180,000. The project is operated primarily for flood control and is part of the comprehensive plan of flood protection in the Naugatuck Valley. It contributes to flood stage reductions at downstream damage centers on the Naugatuck River. In a recurrence of the August 1955 flood, it would prevent $11.7 million in damages.



HOUSATONIC RIVER BASIN
URBAN STUDY

NAUGATUCK RIVER BASIN

NOT TO SCALE

PLATE C-2

Hop Brook Lake

Hop Brook Dam is located 1.4 miles upstream of the mouth of Hop Brook, at the junction of the boundaries of the towns of Middlebury and Naugatuck and the city of Waterbury. Construction of the project started in 1965 and was completed in December 1968 at a cost of $5,575,000. The dam is operated for flood control and is an integral part of the authorized plan for flood control in the Naugatuck Valley. It greatly reduces flood flows in damage centers along the lower Naugatuck River. Operation of the reservoir is coordinated with the operation of Thomaston Dam in times of anticipated downstream flooding. In a recurrence of the August 1955 flood, the flood of record in the Naugatuck Valley, it would prevent $10.3 million in damages.

HYDROMETEOROLOGY

General. The Housatonic basin has a variable climate and frequently experiences periods of heavy precipitation produced by local thunderstorms and large weather systems of tropical and extra-tropical origin. The basin lies in the path of the prevailing "westerlies" which generally travel across the country in an easterly or northeasterly direction producing frequent weather changes. Due to its proximity to the Atlantic Ocean and Long Island Sound, the southern portion of the basin escapes the severe cold and heavy snowfall experienced in the higher elevations in the northern part of the watershed.

Precipitation. The mean annual precipitation over the Housatonic River basin is about 46 inches. The average annual precipitation varies over the basin due to orographic influences, from less than 42 inches in an area east of Candlewood Lake to more than 56 inches at higher elevations along the eastern boundary.

Distribution of the mean precipitation is approximately uniform throughout the year; however, the monthly extremes range from a high of more than 23 inches in August 1955 to less than 0.20 inch on several occasions. Table C-2 summarizes the monthly precipitation at Pittsfield, Massachusetts, and Norfolk, and Bridgeport, Connecticut.

Temperature. The average annual temperature of the Housatonic River basin is about 47° Fahrenheit. Within the basin, average annual temperatures range from 50° near the coast to about 44° Fahrenheit in the higher elevations. Average monthly temperatures vary widely throughout the year, ranging between 65° and 73° Fahrenheit over the basin in July and August, and between 20° and 30° in January and February. Extremes in temperature range from occasional highs just over 100° Fahrenheit to lows in the minus teens in the southern part of the basin and minus twenties in the northern areas. Freezing temperatures may be expected from the latter part of October until late in April. The mean, maximum, and minimum monthly and annual temperatures at selected stations are shown in Table C-3.

TABLE C-2

MONTHLY PRECIPITATION RECORD
(In Inches)

Month	Bridgeport, Connecticut Elevation 7 feet NGVD 87 Years of Record Through 1980			Norfolk, Connecticut Elevation 1380 feet NGVD 48 Years of Record Through 1980			Pittsfield, Massachusetts Elevation 1153 feet NGVD 82 Years of Record Through 1980		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	3.59	7.88	0.40	3.78	8.32	0.93	2.88	6.25	1.13
February	3.48	6.65	0.85	3.71	5.90	1.47	2.67	6.80	0.78
March	4.09	9.64	0.29	4.44	10.37	1.82	3.13	6.63	0.25
April	3.84	9.41	0.69	4.28	7.19	1.15	3.75	6.30	0.63
May	3.77	10.18	0.49	4.06	8.14	1.33	3.63	6.91	0.66
June	3.34	17.70	0.06	4.43	8.73	1.11	3.92	11.38	1.06
July	4.03	18.77	0.45	4.08	9.33	1.29	4.41	12.19	0.48
August	4.14	13.29	0.20	4.21	23.67	0.65	3.42	9.26	0.60
September	3.65	14.15	0.09	4.13	13.40	0.92	3.76	10.50	0.50
October	3.47	10.72	0.30	2.76	17.49	0.63	2.90	8.04	0.06
November	3.86	10.22	0.81	5.05	10.03	1.51	3.55	10.44	0.45
December	3.92	9.85	0.33	4.70	9.56	0.82	2.55	8.88	0.49

TABLE C-3

MONTHLY TEMPERATURES
(Degrees Fahrenheit)

Month	Bridgeport, Connecticut Elevation 7 feet NGVD 85 Years of Record Through 1980			Norfolk, Connecticut Elevation 1380 feet NGVD 41 Years of Record Through 1980			Pittsfield, Massachusetts Elevation 1153 feet NGVD 62 Years of Record Through 1980		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	30.2	68	-22	20.4	62	-22	22.1	65	-22
February	30.9	70	-20	21.3	66	-17	23.8	63	-26
March	37.9	85	1	30.1	77	-11	32.6	80	-11
April	48.4	97	9	43.1	86	6	44.8	91	5
May	58.3	95	26	54.1	87	25	55.0	95	24
June	67.9	99	34	63.0	91	32	63.3	100	33
July	73.8	103	44	67.6	92	41	67.6	101	39
August	72.7	101	38	65.6	93	35	65.4	100	31
September	66.5	98	32	58.6	93	25	58.7	95	23
October	36.8	90	20	48.1	79	17	49.4	89	14
November	46.0	80	9	36.9	73	5	38.9	76	-1
December	32.8	67	-12	24.1	63	-14	26.2	67	-23
Annual	51.9	103	-20	44.4	93	-22	45.7	101	-26

Snowfall. The average annual snowfall over the Housatonic River basin varies from about 35 inches near the coast to over 80 inches in the higher elevations of Massachusetts and northern Connecticut. The mean monthly and annual snowfall at Pittsfield, Massachusetts and Norfolk, and Bridgeport, Connecticut are shown in Table C-4.

Storms. The three general types of storms occurring in the Housatonic River basin are continental, coastal, and those associated with thunderstorms which may be of local origin or the result of a stationary front. Continental storms originate over the western or central part of the United States and move in a general easterly and northeasterly direction. These storms may be rapidly moving intense cyclones or of the stationary type. They are not limited to any season or month, but follow one another at more or less regular intervals with varying intensities throughout the year.

Tropical hurricanes are the most important of the coastal storms. They originate either in the South Atlantic or in the Western Caribbean Sea and generally move in a westerly or northwesterly direction, recurving to the north as they near the mainland, and then to the northeast approaching New England. In general, hurricanes are likely to occur during the months of August and September.

Coastal storms of an extratropical nature differ from the hurricanes principally as they originate along the eastern seaboard and have less energy associated with them. These storms travel northward along the coast, occurring most frequently during the autumn, winter, and spring months. Thunderstorms may be of a local origin or the frontal type associated with the summer months.

Runoff

Discharge Records. The U.S. Geological Survey has published records for 23 gaging stations in the Housatonic River basin for varying periods of time since 1900. Pertinent data for 16 current stations are summarized in Table C-5.

Streamflow Data. The average annual runoff on the Housatonic River at Stevenson, Connecticut, which encompasses 1,545 of the total area of 1,949 square miles of the Housatonic River basin, is 22.4 inches. This compares with the average annual runoff of 25.9 inches for the Naugatuck River at Beacon Falls, Connecticut. These values represent approximately 50 percent of the average annual percipitation.

TABLE C-4

MEAN MONTHLY SNOWFALL
(Average Depth in Inches)

	Pittsfield, Massachusetts Elevation 1153 feet NGVD 49 Years of Record Snowfall	Norfolk Connecticut Elevation 1380 feet NGVD 37 Years of Record Snowfall	Bridgeport, Connecticut Elevation 7 feet NGVD 76 Years of Record Snowfall
January	17.4	21.2	8.7
February	17.9	22.5	10.0
March	11.9	21.0	6.5
April	3.7	7.6	1.1
May	0.1	0.3	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0.2	0.5	0
November	5.6	7.6	1.4
December	12.0	18.3	6.5
Annual	68.5	99.0	34.2

TABLE C-5

HOUSATONIC RIVER BASIN
CURRENT STREAMFLOW RECORDS THROUGH WATER YEAR 1980

Location of Gaging Station	Drainage Area (sq. mi.)	Period of Record	Discharge (cfs) Mean	Maximum	Minimum
East Br. Housatonic R. at Coltsville, Mass.	57.1	1936-1980	115	6,400 9/21/38	4.4 8/15/36
Housatonic R. near Great Barrington, Mass.	280	1913-1980	529	12,200 1/1/49	1.0 10/18/14
Housatonic R. at Falls Village, Conn.	634	1912-1980	1090	23,900 8/19/55	*
Tenmile R. near Gaylordsville, Conn.	203	1929-1980	305	17,400 8/19/55	5.0 9/8/57
Pomperaug R. at Southbury, Conn.	75	1932-1980	128	29,400 8/19/55	2.5 8/30/66
Housatonic R. at Stevenson, Conn.	1541	1928-1980	2622	75,800 10/16/55	*
West Br. Naugatuck R. at Torrington, Conn.	33.7	1956-1980	59.3	8,820 9/26/75	0.3 8/21/68
East Br. Naugatuck R. at Torrington, Conn.	13.7	1956-1980	24.7	1,500 8/5/69	0.3 8/24/64
Naugautck R. at Thomaston, Conn.	99.2	1959-1980	203	5,140 3/31/60	8.4 8/14/64
Housatonic R. at Gaylordsville, Conn.	993	1940-1980	1701	51,800 8/19/55	60.0 8/31/44
Naugatuck R. at Beacon Falls, Conn.	259	1918-1980	496	106,000 8/19/55	24 10/21/35
Salmon Creek at Limerock, Conn.	29.4	1961-1980	48.8	1,840 3/6/79	0.7 9/25/64
Guinea Brook at Ellsworth, Conn.	3.5	1960-1980	7.04	319 12/22/73	0

TABLE C-5 (Cont'd)

Location of Gaging Station	Drainage Area (sq. mi.)	Period of Record	Discharge (cfs) Mean	Maximum	Minimum
Marshepaug R. near Milton, Conn.	9.24	1967-1980	20.9	474 12/22/73	0.22 7/31/77
Branch Brook near Thomaston, Conn.	21.3	1971-1980	37.6	795 9/28/75	0.7 6/22/73
Hop Brook near Naugatuck, Conn.	16.3	1969-1980	37	535 12/12/73	0.06 6/20/70

* No flow at times (result of regulation)

MASSACHUSETTS

Water Quality. To achieve the objectives of the Massachusetts Clean Waters Act and the Federal Water Pollution Control Act Amendments of 1972 and to assure the best use of the waters of the Commonwealth the following standards were adopted and shall be applicable to all waters of the Commonwealth or to different segments of the same waters:

Class A - These waters are designated for use as sources of public water in accordance with the provisions of Chapter 111 of the General Laws.

Class B - These waters are suitable for bathing and recreational purpose, water contact activities, acceptable for public water supply with treatment and disinfection, are an excellent fish and wildlife habitat, have excellent aesthetic values and are suitable for certain agricultural and industrial uses.

Class C - These waters are suitable for recreational boating and secondary water contact recreation, as a suitable habitat for wildlife and fish indigenous to the region, for certain agricultural and industrial uses, have good aesthetic values, and under certain conditions are acceptable for public water supply with treatment and disinfection.

Class U - These waters are considered unsatisfactory. Plate C-3 shows the present condition of rivers and streams in the Massachusetts portion of the Housatonic Basin.

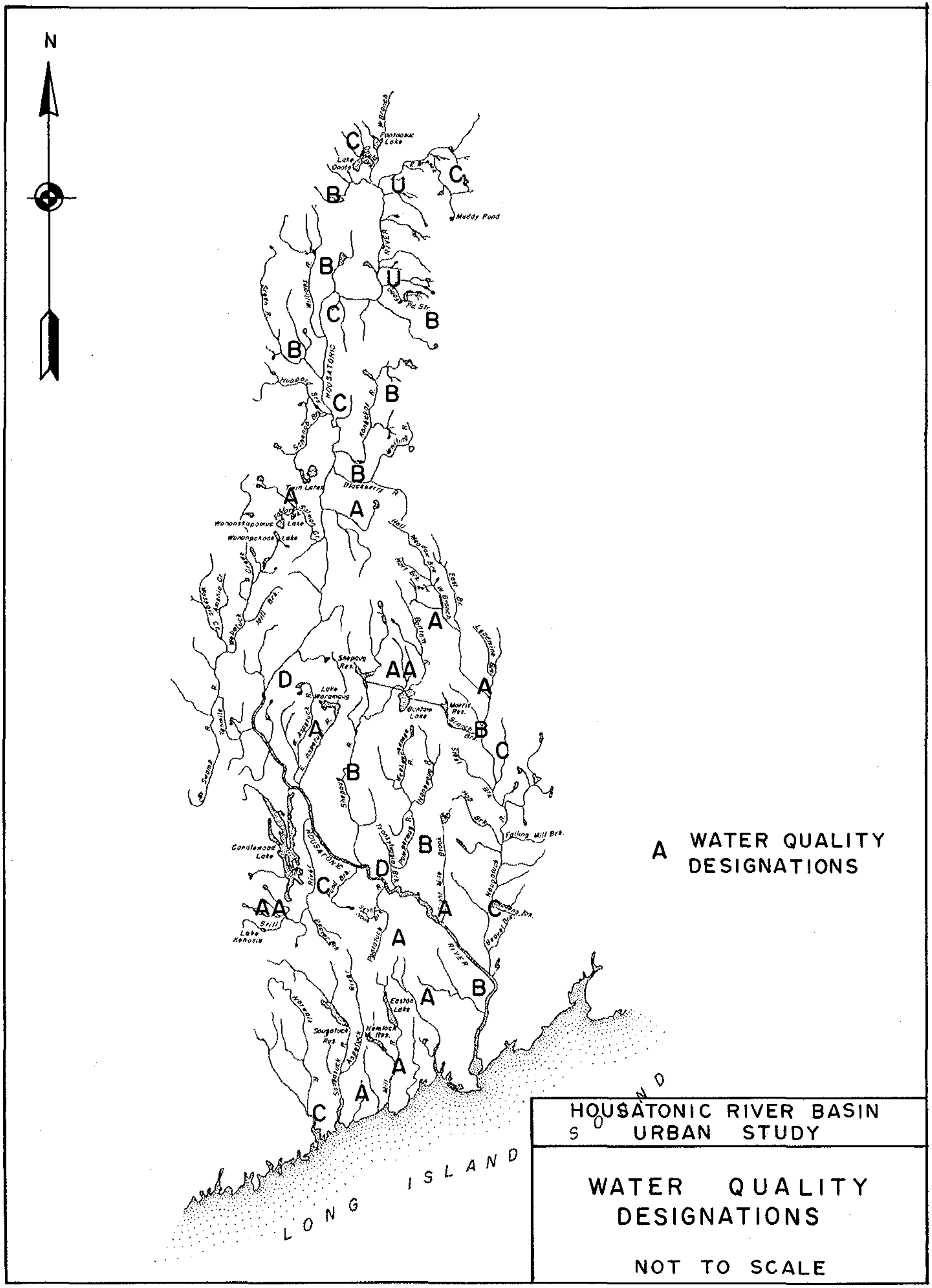
CONNECTICUT

The Water Quality Standards adopted by the State of Connecticut in accord with all the requirements of Section 25-54e of the Connecticut General Statutes are as follows:

Class AA - Existing or proposed drinking water supply impoundments and tributary surface waters.

Class A - May be suitable for drinking water supply and/or bathing; suitable for all other water uses; character uniformly excellent; may be subject to absolute restrictions on the discharge of pollutants; authorization of new discharges of other than minor cooling and clean water or dredge materials at designated locations would require revision of the class to Class B which would be considered concurrently with the issuance of a permit at public hearing.

Class B - Suitable for bathing, other recreational purposes, agricultural uses, certain industrial processes and cooling; excellent fish and wildlife habitat; good aesthetic value.



HOUSATONIC RIVER BASIN URBAN STUDY

WATER QUALITY DESIGNATIONS

NOT TO SCALE

PLATE C-3

Class C - Suitable for fish and wildlife habitat, recreational boating, and certain industrial processes and cooling; good aesthetic value.

Class D - Considered Unacceptable.

The existing water quality classification of the various rivers and streams in the Connecticut portion of the Housatonic Basin are shown on Plate C-3.

STREAMFLOW

General. Industrial and commercial development has been confined to the lower portion of the basin in Connecticut, particularly in the Naugatuck River Valley. Some of the commercial centers and many of the factories and mills in these areas are located on banks of the rivers. The river channels in many reaches are restricted by buildings, walls and bridges. Concentration of runoff and steep hydraulic gradients throughout the flood prone areas also produce damaging velocities. Roads, bridges, railroads, buildings and lands along the streams are all susceptible to damage from flooding.

Except for concentrations in the Pittsfield, New Milford and Derby-Shelton areas flood damage along the main stem of the Housatonic River is widely scattered. Due to the lengthy travel time and great amount of valley storage near the central portion of the watershed, flood peaks in the lower basin are produced by the tributaries just upstream of the damage centers. The most important Housatonic River index station is the USGS gage at Stevenson Dam.

Most of the flood plain along the Naugatuck River has been utilized by industrial, commercial and residential developments. In some areas the river channel is restricted by buildings, dams and bridges which permit the formation of debris dams with resulting increase in flood levels. Lack of valley storage and short time of concentration characterized by steep tributaries in the watershed produce very high rates of runoff. The USGS gage at Beacon Falls is the primary index station on the Naugatuck. Maintaining flows at Beacon Falls below 8,250 cfs, stage of 10 feet, will normally result in the passage of nondamaging floodflows along the entire length of the Naugatuck River. Flood levels in the Ansonia-Derby area are also affected by abnormally high tide conditions associated with hurricanes or severe coastal storms.

Downstream Channel Capacities. A tabulation of the maximum non-damaging channel capacities immediately downstream of the three major Corps flood control projects follows:

	Channel Capacity	
	CFS	CSM
Thomaston Dam	3,500+	36
Black Rock Lake	800+	39
Hop Brook Lake	550+	34

A tabulation of the regulated peak discharges from the three manned reservoirs is listed in Table C-6.

Stream Encroachment Lines. The State of Connecticut, Department of Environmental Protection is responsible for establishing stream encroachment lines along flood prone areas within the following framework:

> "The Commissioner shall establish, along any tidal or inland waterway or flood prone area considered for stream clearance, channel improvement or any form of flood control or flood alleviation measures, lines beyond which, in the direction of the waterway or flood prone area, no obstruction of encroachment shall be placed by any person, firm or corporation, public or private, unless authorized by said Commissioner. The Commissioner shall issue or deny permits upon applications for establishing such encroachments based upon his findings of the effect of such proposed encroachments upon the flood carrying and water storage capacity of the waterways and flood plains, flood heights, hazards to life and property, and the protection and preservation of the natural resources and ecosystems of the state, including but not limited to ground and surface water, animal, plant, and aquatic life, nutrient exchange, and energy flow, with due consideration given to the results of the control or flood alleviation measures, lines beyond which, in the direction of the waterway or flood prone area, no obstruction of encroachment shall be placed by any person, firm or corporation, public or private, unless authorized by said Commissioner. The Commissioner shall issue or deny permits upon applications for establishing such encroachments based upon his findings of the effect of such proposed encroachments upon the flood carrying and water storage capacity of the waterways and flood plains, flood heights, hazards to life and property, and the protection and preservation of the natural resources and ecosystems of the state, including but not limited to ground and surface water, animal, plant, and aquatic life, nutrient exchange, and energy flow, with due consideration given to the results of similar encroachment constructed along the reach of waterway."

TABLE C-6

REGULATED PEAK DISCHARGES AT MANNED RESERVOIRS

Naugatuck River**
at Thomaston
(DA = 101 square miles)

Date	Gage Height (ft)	Discharge (cfs)
31 Mar 1960	6.25	5,140
28 Feb 1961	5.23	3,090
3 Apr 1962	4.37	1,780
29 Mar 1963	4.46	1,900
27 Jan 1964	4.29	1,680
9 Feb 1965	4.09	1,430
3 Mar 1966	3.43	764
20 Apr 1967	3.92	1,230
22 Mar 1968	4.58	2,060
8 Aug 1969	4.53	1,990
8 Apr 1970	4.49	1,950
16 Sep 1971	4.04	1,370
24 Mar 1972	4.46	1,900
8 Dec 1972	4.82	2,410
6 Feb 1973	4.75	2,300
31 Oct 1973	4.51	1,960
23 Dec 1973	5.30	3,220
22 Mar 1974	4.27	1,650
29 Sep 1975	5.61	3,810

Branch Brook**
near Thomaston
(DA = 20.6 square miles)

Date	Gage Height (ft)	Discharge (cfs)
14 Sep 1971	3.11	494
19 Mar 1972	2.98	411
7 Dec 1972	3.87	684
6 Feb 1973	3.68	580
22 Dec 1973	3.45	468
22 Mar 1974	3.30	440
28 Sep 1975*	4.05	795

Hop Brook
near Naugatuck**
(DA 16.4 square miles)

Date	Gage Height (ft)	Discharge (cfs)
5 Feb 1970	3.88	482
11 Feb 1971	3.48	334
13 Sep 1971	3.22	256
14 Mar 1972	3.35	295
7 Dec 1972	3.62	378
6 Feb 1973	3.76	440
1 Jul 1973	3.80	460
22 Dec 1973	3.95	535
22 Mar 1974	3.68	403
28 Sep 1975	3.92	520

*Gage relocated downstream to Route 6 bridge (DA = 21.3 square miles)
**Tailwater gates immediately downstream of Thomastonn Dam, Black Rock Lake and Hop Brook Lake, respectively.

Following is a tabulation of the 16 communities within the Housatonic River basin for which stream encroachment lines have been established:

Ansonia	Naugatuck	Thomaston
Beacon Falls	New Milford	Torrington
Danbury	North Canaan	Washington
Derby	Norfolk	Waterbury
Harwinton	Plymouth	Watertown
	Seymour	

FLOODS OF RECORD

General. The Housatonic River basin is susceptible to destructive floods caused by ice, heavy rainfall, melting snow or some combination thereof. Floods may occur at any time of the year, and runoff is rapid, particularly on tributaries where the topography is hilly. The floods of August and October 1955 were caused by intense rainfall, while the March 1936 event was the result of heavy rainfall and considerable snowmelt.

Historic Floods. The flood history of the Housatonic River basin extends back to the first settlers, about 300 years ago. Information pertaining to flooding in this area was obtained through field investigations and research of published U.S. Geological Survey data and newspaper accounts.

Records of floods in the Housatonic River basin prior to the turn of the century are meager. From available information, the largest known flood prior to 1900 occurred in October 1869, with noteworthy events of the period occurring in 1886, 1888 and 1897.

In the Naugatuck River watershed, the earliest flood of significance occurred in February 1691, with two other events of the same magnitude taking place in November 1853 and April 1854. A damaging flood occurred in January 1891, while the October 1869 flood was the largest event prior to 1900. The order of magnitude of these floods is not known; however, they were all smaller than the August and October 1955 events.

Recent Floods. Since 1900, more than 10 events of varying severity have been experienced in the Housatonic River basin. The floods of August 1955 and October 1955 surpassed all other recorded discharges in the Naugatuck watershed and most of the Housatonic River basin. A tabulation of discharges for the largest recorded floods at selected gaging stations is presented in Table C-7. Descriptions of the most destructive floods during the last 55 years follow:

November 1927. A tropical storm formed over the Carribean late in October 1927, commenced northward 1 November and was at the lower end of Chesapeake Bay by 3 November. The storm followed a path over western Connecticut, Massachusetts and Vermont, causing the greatest flooding on

TABLE C-7

MAJOR FLOODS
HOUSATONIC RIVER BASIN
(Through 1974)

Location	Drainage Area (sq.mi.)			Peak Discharge CFS	CSM
Housatonic River near Great Barrington	280	January	1949	12,200	44
		September	1938	11,520	41
		March	1936	8,990	32
		November	1927	7,910	28
		August	1955	6,060	22
Housatonic River at Stevenson	1,545	October	1955	75,800	49
		March	1936	69,500	45
		August	1955	69,400*	45
		September	1938	59,500	38
		December	1948	51,800	34
Naugatuck River at Beacon Falls	261	August	1955	106,000	406
		October	1955	30,400	116
		December	1948	28,500	109
		November	1927	26,000	100
		September	1938	25,300	97
Still River near Lanesville	68.5	October	1955	7,980	117
		September	1938	4,410	64
		March	1936	3,930	57
		August	1955	3,920	57
		February	1941	3,800	55

*Without benefit of storage at Lake Lillinonah, it is estimated that the peak discharge would have been over 100,000 cfs (56 csm).

the Vermont tributaries of the Connecticut River and flooding in New Hampshire, western Massachusetts and Connecticut. Storm rainfall on 2-4 November at Waterbury and Cream Hill, Connecticut and Pittsfield, Massachusetts was 5.1, 5.4 and 5.7 inches, respectively.

March 1936. During the second week of March 1936, temperatures in New England became unseasonably warm and continued for the remainder of the month. Snow cover in the upper portions of the Housatonic River basin was above average since little thawing had occurred in January and February. During the period 9-22 March, three storm centers passed over New England, with heavy rainfall on 11-12 and 17-18 March. The total storm rainfall for the month at Bridgeport, Waterbury and Cream Hill, Connecticut and Pittsfield, Massachusetts was 6.5, 8.9, 6.9, and 5.9 inches, respectively. Total runoff for the month at the Stevenson gage was 9.7 inches.

September 1938. A stationary cold front along the Atlantic coast was overrun by a rapidly moving tropical hurricane, producing record breaking rainfall over large areas of Connecticut, Massachusetts and New Hampshire. The storm which started with light rain, gradually increased in intensity over the 4-day period and produced heavy downpour associated with the hurricane. The total storm rainfall averaged about 9 inches for the period 17-21 September. Precipitation at Bridgeport, Waterbury, Cream Hill and Pittsfield was 11.2, 9.1, 10.1 and 7.3 inches, respectively. Total runoff for the period 20-28 September at Stevenson was 5.4 inches. In the lower reaches of the Housatonic River, the flood occurred almost simultaneously with the abnormally high hurricane tide, causing significant flooding in the tidal reach.

December 1948 - January 1949. The "New Year's" storm of 1949, typical of winter cyclonic events of continental origin, was characterized by a low pressure area which deepened and intensified as it moved northward from the Middle Atlantic coast. Upon approaching the New England area, the northward movement of the low pressure area became blocked by an area of high pressure over the North Atlantic Ocean and the circulating warm moist air became mixed with the cold air, resulting in intense rainfall over eastern New York State and western New England. Rain fell on partially frozen ground, ranging up to 10 inches over portions of the Housatonic River basin. Total precipitation for 29 December through 26 January for Waterbury, Cream Hill and Pittsfield was 7.7, 8.6, and 8.1 inches, respectively. Total runoff for the period 30 December through 12 January at Stevenson was 5.9 inches. Snowmelt was a minor factor early in the flood, and in general, had little effect on the magnitude of the peak discharges.

August 1955 Storm. The hurricane "Diane" storm of August 1955 produced record-breaking floods throughout much of southern New England. The accompanying rains fell on ground previously saturated by rainfall from hurricane "Connie" which occurred one week earlier. Rainfall amounts, for the period from the 17 to 20 August, ranged from 5 to 13 inches over the Housatonic River basin. Recorded 24-hour totals were in excess of 8 inches at several stations within the lower portion of the basin. For instance, total precipitation for the period 17-20 August for Cream Hill and Torrington was 9.6 inches and 13.3 inches, respectively. Total runoff at Stevenson for the period 19-26 August was 4.8 inches, while total runoff on the Naugatuck River at Naugatuck for the period 18-23 August was 11.9 inches from the contributing 246 square mile drainage area.

Following the event the Corps of Engineers constructed small dikes, repaired existing dikes, placed riprap around bridges and cleared channels throughout the entire Housatonic basin. Significant emergency operations were performed in Thomaston, Waterbury, Ansonia, Litchfield, Bethlehem and Winchester, Connecticut.

October 1955. The storm of 14-17 October originated as an extra-tropical low pressure area off the Florida coast. The northward moving low pressure system became stalled south of the New England coastline. The warm, moist tropical air circulating about the low pressure area overran cooler air over New England and intense rainfall resulted over most of southern New England. The heaviest rainfalls occurred over western Massachusetts and Connecticut, including portions of the Housatonic River basin where amounts of approximately 12 inches were recorded during the 72-hour storm period. Total precipitation between 14-17 October at Ansonia, Bridgeport, Cream Hill and Torrington was 9.5, 7.2, 5.9 and 10.4 inches, respectively. Total runoff at Stevenson for the 1,545 square mile drainage area between 15-22 October was 5.0 inches, while the Naugatuck River at Naugatuck experienced 8.1 inches of runoff between 15-25 October.

June 1972. The June 1972 event was produced by a storm rainfall between 6 and 7 inches occurring mostly in a 24-hour period on the 18th and 19th of June. This storm over southern Connecticut was separate from, but somewhat of a forerunner of the great "Agnes" storm of the 21st and 22nd of June which, fortunately for southern New England, turned westward from its northerly course, entering New York and Pennsylvania. Had "Agnes" continued its northerly course into southern New England, following the storm of 18-19 June, a flood disaster could have occurred.

June 1982. This flood was the most recent to effect Connecticut. In some areas the rainfall was over 14 inches for the three day period between 6-9 June. The storm primarily effected the smaller basins along the coast. The large river basins extending into the northern portion of Connecticut and into Massachusetts did not sustain major flooding. It was estimated to be a 15-year storm along the Pomperaug River in Southbury but less than a 2-year storm along the Housatonic River in the same area. Along the Quinnipiac River in Wallingford, Connecticut, which is not in the study area, the storm was estimated to be a 200-year storm.

Flood Profiles. Flood insurance studies were the largest source of data on synthetic floods, elevations of bridges and dams, and channel invert elevations. Table C-8 lists the 10-, 50-, 100- and 500- year flood discharges obtained from these studies.

ANALYSIS OF FLOODS

Housatonic River. Floodflows and precipitation records were analyzed to determine the runoff characteristics of the Housatonic River basin such as: (1) time of year when floods may occur, (2) effect of topography, and (3) relative timing and flood peak contributions at downstream damage centers. The analysis resulted in the following conclusions:

The basin responds quickly to periods of intense rainfall which may occur in any month and as a result, there is no flood free season of the year. The spring snowmelt is not of damaging magnitude unless augmented by rainfall. Although there are a number of moderate to steep tributary slopes throughout the basin, the lakes, ponds, swampy areas and natural valley storage upstream of Falls Village result in moderate main stem runoff characteristics.

Rapid runoff from the headwaters of the East and West Branches of the Housatonic River, combined with artificial and natural restrictions, cause flooding in the city of Pittsfield, Massachusetts. Several tributaries with characteristics conducive to high rates of runoff discharge into the reach between Pittsfield and Great Barrington, Massachusetts where the river falls about 280 feet in 30 miles. However, the vast amount of storage in the main river valley, falling about 45 feet in 24 miles, retards and modifies these discharges so that their peak contributions occur on the recession side of the flood hydrographs at downstream locations. Flood peaks on the Housatonic River from Falls Village to Derby are largely produced by the drainage area below the Connecticut-Massachusetts state line. Flood stages in the tidal reach downstream of Derby and Shelton may be produced by a combination of concurrent flows in the Housatonic and Naugatuck Rivers and abnormal high tides from severe coastal storms or hurricanes.

Naugatuck River. The Naugatuck River can also experience flooding in any season of the year; however, the majority of significant events experienced in the watershed have been associated with tropical storms. With a uniform slope of about 14 feet per mile on the mainstem and steep tributaries, the watershed is quite sensitive to periods of intense rainfall, and floodflows develop rapidly.

The only appreciable amounts of storage are located in man-made flood control projects. There are seven Corps of Engineers projects that control approximately 50 percent of the watershed's drainage area at its confluence with the mainstem.

TABLE C-8

FLOOD INSURANCE STUDY - DISCHARGES

Housatonic River	Drainage Area (sq.mi.)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)	500-Yr (cfs)
Stratford At Stratford, CT	1,890	57,000	125,000	170,000	330,000
Milford Below Naugatuck River	1,890	60,000	125,000	170,000	330,000
Shelton Below Naugatuck River	1,889	55,000	120,000	170,000	220,000
Orange Below Naugatuck River	1,889	55,000	120,000	170,000	220,000
Shelton Above Naugatuck River	1,578	45,000	90,000	130,000	198,000
Seymour Above Shelton Dam	1,574	45,000	90,000	130,000	198,000
Oxford At Stevenson Gaging Sta.	1,541	42,000	87,000	126,000	196,000
Newtown Above Stevenson Dam	1,541	42,000	87,000	126,000	196,000
Southbury Southbury-Oxford Town Line	1,522	42,000	87,000	126,000	196,000
New Milford Downstream Study Limit	1,198	27,080	56,210	76,400	127,640
New Milford Downstream of Still River	1,194	27,000	55,850	75,790	126,550
New Milford Upstream of Still River	1,123	25,540	49,610	65,500	108,190
New Milford Downstream of Great Brook	1,120	25,375	49,360	65,090	107,468
New Milford Downstream of E. Aspetuck R.	1,115	25,470	48,930	64,400	106,230
New Milford Upstream of E. Aspetuck R.	1,065	24,340	44,780	57,740	99,480
New Milford Boardman Bridge	1,022	23,450	41,360	52,350	85,030
New Milford Upstream Study Limit	1,017	23,350	40,970	51,740	83,970
Kent Kent-New Milford Corp. Limit	782	21,670	37,110	46,440	75,220
Kent Bulls Bridge	781	21,600	37,000	46,300	75,000

TABLE C-8 (Cont'd)

FLOOD INSURANCE STUDY - DISCHARGES

Housatonic River	Drainage Area (sq.mi.)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)	500-Yr (cfs)
Kent 3.02 miles south of the Rte 341 Structure	775	21,230	36,360	45,490	73,670
Kent 1.56 miles south of the Rte 341 Structure	766	20,660	35,400	44,270	71,680
Kent Rte 341 Structure Crossing Housatonic River	756	20,040	34,330	42,910	69,460
Kent 3.66 miles south of Kent-Sharon Corp. Limits	742	19,170	32,840	41,010	66,360
Kent 1.44 miles south of Kent-Sharon Corp. Limits	728	18,290	31,350	39,110	63,260
Kent Kent-Sharon Corp. Limits	719	17,730	30,390	37,900	61,270
Sheffield Ct-Mass State Line	535	10,335	16,495	19,730	29,180
Sheffield Rte 7A	468	9,435	14,880	17,725	25,870
Sheffield D/S Hubbard Brook	448	9,160	14,390	17,120	24,875
Sheffield U/S Hubbard Brook	398	8,431	13,135	15,570	22,360
Great Barrington Corp. Limit	394	8,394	13,035	15,445	22,160
Great Barrington U/S Green River	341	7,592	11,660	13,760	19,460
Great Barrington Division St Gage	280	6,640	10,000	11,700	16,300
Stockbridge Rising Dam	278	6,625	9,980	11,680	16,275
Stockbridge Rte 7	248	6,365	9,675	11,350	15,900
Stockbridge Willow Mill	243	6,320	9,620	11,290	15,830

TABLE C-8 (Cont'd)

FLOOD INSURANCE STUDY - DISCHARGES

Still River	Drainage Area (sq.mi.)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)	500-Yr (cfs)
New Milford @ Confluence w/Housatonic River	71.5	2,995	7,130	9,875	19,965
New Milford 850' D/S of Creamery Rd	71.0	2,980	7,100	9,835	19,880
New Milford 50' D/S of Creamery Rd	69.7	2,925	6,970	9,655	19,515
New Milford 3100' U/S of Cross Rd Bridge	67.2	2,820	6,720	9,305	18,515
New Milford 720' D/S of Aldrich Rd Bridge	66.1	2,790	6,640	9,195	18,590
Brookfield D/S Corporate Limit	66.1	2,820	6,720	9,305	18,815
Brookfield U/S of Aldrich Road	65.8	2,790	6,640	9,195	18,590
Brookfield D/S of Limekiln Brook	65.6	2,755	6,560	9,085	18,370
Brookfield U/S of Limekiln Brook	63.6	2,670	6,360	8,810	17,810
Brookfield U/S of Relocated Silver Mine Rd	62.0	2,605	6,200	8,585	17,360
Brookfield D/S of Relocated U.S. Hgwy 7	59.6	2,505	5,960	8,255	16,690
Brookfield D/S of East Brook	58.3	2,450	5,830	8,075	16,375
Brookfield U/S Corporate Limit	56.7	2,380	5,670	7,850	15,875
Danbury From Frequency-Discharge Drainage Area Curves	50.0	2,150	4,900	6,900	13,800
Danbury From Frequency-Discharge Drainage Area Curves	40.0	1,800	3,900	5,650	10,900
Danbury From Frequency-Discharge Drainage Area Curves	30.0	1,400	3,050	5,350	8,450
Danbury From Frequency-Discharge Drainage Area Curves	20.0	950	2,100	3,050	6,100
Danbury From Frequency-Discharge Drainage Area Curves	14.0	750	1,650	2,400	4,800

TABLE C-8 (Cont'd)

FLOOD INSURANCE STUDY - DISCHARGES

Pomperaug River	Drainage Area (sq.mi.)	10-Yr (cfs)	50-Yr (cfs)	100-Yr (cfs)	500-Yr (cfs)
Southbury Confluence w/Housatonic River	88.7	7,000	15,000	21,000	42,000
Southbury Dam @ South Britain	79.3	6,000	13,000	18,000	36,000
Woodbury Woodbury-Southbury Town Line	67.0	6,000	13,000	18,000	36,000
Woodbury Confluence w/Nonewaug and Weekeepeemee R.	54.0	6,000	13,000	18,000	36,000

As the result of the above data and the flood insurance study profiles that were available, plans and profiles were developed for the Housatonic River, Still River and the Pomperaug River.

There is no other significant river storage in the 39 mile river length that in any way contributes to flood control, peak reduction, or desynchronization. In the future, any flooding in the lower reaches of the Naugatuck will be a direct result of runoff from the uncontrolled drainage areas downstream of Corps projects.

Still River. Floods in the Still River may occur during any season of the year as a result of either intense rainfall over the watershed or from rainfall in conjunction with melting snow such as the flood of March 1936. However, the largest floods have developed from rainfall associated with tropical storms such as the August and October 1955 events.

The lower reach of the Still River downstream of Danbury has a comparatively flat gradient and contains a large amount of natural valley storage and for this reason peaks tend to be smaller but of longer duration in this area than in Danbury.

Ice Jam Flooding. During the spring runoff period ice jam flooding is possible in the Housatonic River basin at the following locations.

(1) Housatonic River at Route 20 in Pittsfield

(2) Housatonic River at the West Cornwall covered bridge

(3) Housatonic River at Kent just upstream of the Bulls bridge hydroelectric station

(4) Housatonic River at New Milford at Lovers Leap Gorge immediately downstream of the Still River confluence

(5) West Branch Naugatuck River just downstream of its confluence with Hall Meadow Brook

Tidal Flooding. The lower 12-mile reach of the Housatonic River from its mouth to Shelton Dam and 2.5 miles along the Naugatuck River above the confluence, is a tidal estuary. Flood stages in this area are produced by freshwater flood discharges, abnormally high tides, or a combination of both.

DROUGHTS

General. The Housatonic River basin lies within the general zone classified as humid, where average annual precipitation is distributed evenly throughout the year. In National Weather Service terminology, a drought is considered to be a period of 14 or more days in which less than 0.1 inch of precipitation falls in a 48-hour period. To the agriculturist, a drought is a lack of soil moisture during the growing season. Hydrologically, a drought is defined as a prolonged period of precipitation deficiency which seriously affects riverflow as well as surface and ground water supplies. Periods of deficient precipitation and runoff have occurred in the watershed.

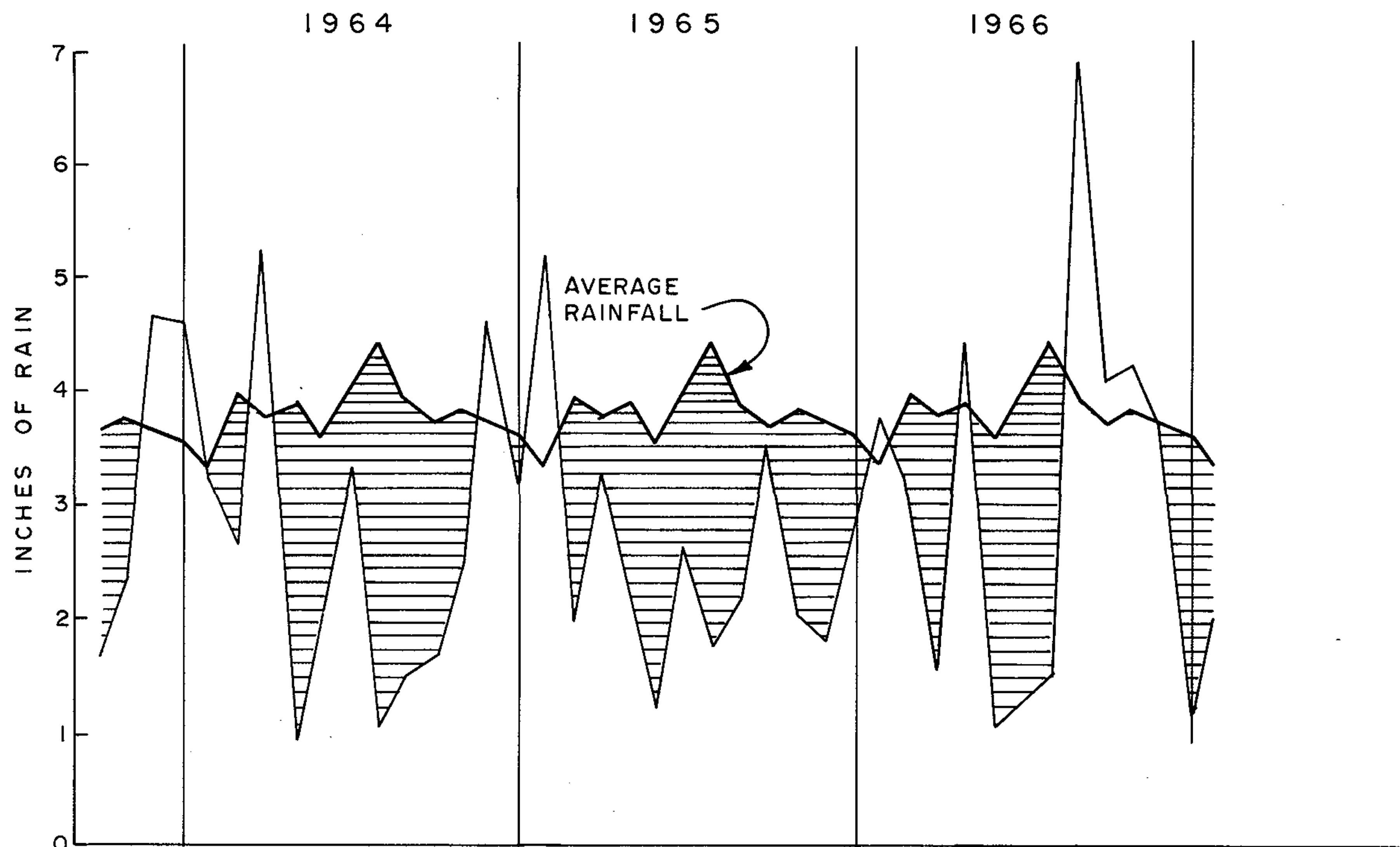
History. The drought history in the basin extends back more than 100 years. Since the establishment of stream gaging stations within the watershed in the early part of this century, two rather extensive periods have occurred when recorded amounts of runoff in the watershed were far below normal. The first occurred during water years (October thru October) 1930 through 1932, inclusive and the second, and most severe, began in the latter part of water year 1961 and extended through the middle of water year 1966.

Drought of 1961-1966. The greatest and most severe drought in the history of the Housatonic River basin occurred in water years 1961 through 1966. During this period, the cumulative precipitation deficiencies at Bridgeport and Cream Hill, Connecticut and Pittsfield, Massachusetts were 92.0, 79.6 and 51.7 inches, respectively, which are 50, 58 and 79 percent of the average annual precipitation. The cumulative runoff deficiencies for water years 1961-1966 for the Housatonic River at Falls Village and Stevenson, Connecticut and on the Naugatuck River at Beacon Falls were 42.6, 44.5 and 37.4 inches, respectively, which are 53, 50 and 65 percent of the average annual runoff. Rarely is a deficiency of ground water carried over from one growing season to the next in New England, since it is replenished during each spring runoff. However, this condition occurred in the winter of 1964-1965 and resulted in a record low flow runoff in water year 1965 at Falls Village, Stevenson and Beacon Falls of 8.7, 8.5 and 11.7 inches, respectively, which are 38, 38 and 48 percent of the average annual runoff. Plate C-4 graphically depicts the average monthly rainfall for the 1964-1966 drought period.

Recent Drought. The most recent drought to effect the study area occurred in 1980-1981. The total rainfall in the southwestern Connecticut area between August 1980 and August 1981 was less than 33 inches. This total rainfall is equal in magnitude to that of the 1960's drought. The difference is that during the 1960's the total yearly rainfall remained in the 30's for three consecutive years. The five months between September 1981 and January 1982 have had excessive precipitation, well above the average. Therefore, the chances of a significant prolonged drought diminished. The average monthly rainfall for the 1979-1981 period is shown on Plate C-5.

GROUNDWATER

The groundwater effort for this study in Connecticut has been coordinated very closely with the Aquifer Assessment Program (AAP). The sites being investigated by the Corps are a result of a screening process undertaken by the Connecticut Department of Environmental Protection and the United States Geological Survey for the AAP. There were eight aquifers in the southwest area identified as having some potential for development as municipal water supply sources. These aquifers were undergoing detailed investigation by the DEP and USGS when the program got a cut in funding in July 1980.

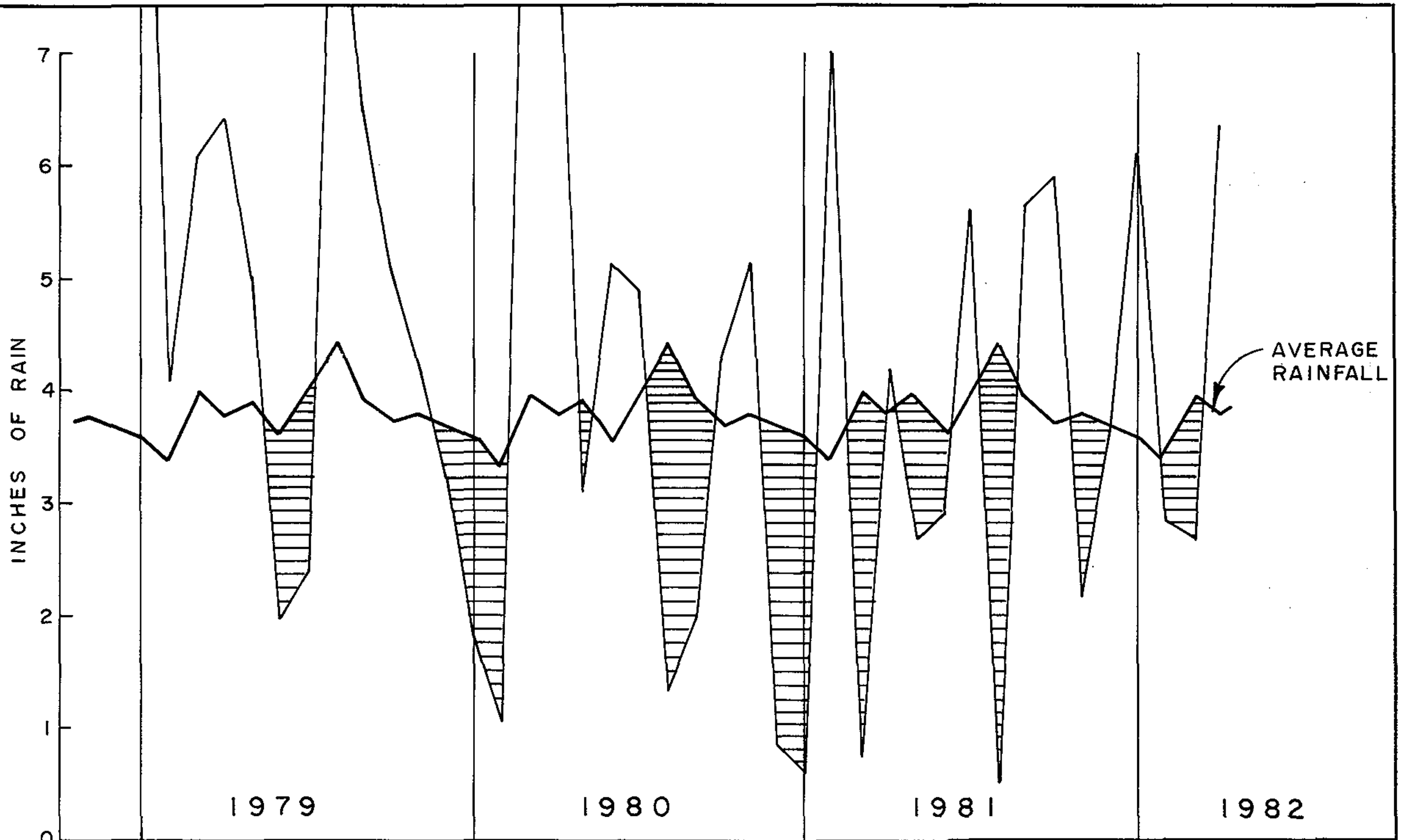


HOUSATONIC RIVER BASIN
URBAN STUDY

1960'S DROUGHT

NOT TO SCALE

PLATE C-4



HOUSATONIC RIVER BASIN URBAN STUDY

1980'S DROUGHT

NOT TO SCALE

PLATE C-5

There are three other aquifers located along the coast that were not included in the AAP because they had been modelled by the USGS in their Water Resources Bulletin #17.

There was no attempt to date to determine the water quality of the aquifers used in the alternative plans. The intent of this initial study was to identify the potential sources of water and where they could best be utilized. The following is a discussion of the Aquifer Assessment Program:

The Interagency Water Resources Planning Board (IWRPB), composed of representatives from the State's Departments of Health Services and Environmental Protection and Office of Policy and Management is the organization within State government charged with formulating the State's long-range water resources management plan.

Utilizing a combination of factors including population projections, potentials of existing water supply service to meet demands and local zoning, the IWRPB has identified on a preliminary basis, areas and regions in the State that will have potential water supply problems under conditions of continued growth or climatic stress (long-term drought similar to that experienced in the 1960's). Southwestern Connecticut was identified as being the most vulnerable to water supply shortages by the IWRPB.

The Southwestern Connecticut Aquifer Assessment Program was initiated on June 21, 1979 by the approval of Special Act No. 79-94. This act and Substitute House Bill No. 7694 mandated the Connecticut Department of Environmental Protection to conduct an aquifer assessment in southwestern Connecticut effective July 1, 1979.

From the available data it was estimated that there were approximately 10-12 stream aquifer systems in the region conducive to water supply development by wells. This estimate was based on a number of factors including, but not limited to, size and thickness of the aquifer, size of the drainage area contributing water to the aquifer and associated surface water body, degree of urban development overlying the aquifer, proximity to saline surface water, presence of known contaminant discharges to the aquifer or associated surface water body and degree of presnt withdrawals of water by wells.

As of February 1, 1980 five stream aquifer systems were in stages of preliminary modeling.

Data collection and analysis has consisted mainly of geophysical surveys and testborings to supplement existing information. Thirty-four testborings have been completed at depths up to 125 feet with appropriate materials samples being collected. Twenty-five of the borings have been screened and cased to allow for the monthly measurement of groundwater levels. The wells have been developed by pumping to facilitate the later collection of water samples for quality analyses.

Seismic surveys have been conducted at 19 individual sites covering a total of 19,000 linear feet. Computer interpretation of that data has been completed.

The planned termination of the Southwestern Aquifer Assessment Program was for the end of FY'1982 and would yield 10 - 12 ground water models and water quality assessments of the stream/aquifer systems as products. A published report containing the models, the quality assessments and an overview of the groundwater availability conditions for the entire Southwestern area would have been available for distribution by October 1, 1982.

The completed, calibrated models would have given well yields for hypothetical wells in each stream/aquifer system, but more importantly, they would allow state and local officials to make sound decisions on a number of land and water uses including water supply and waste disposal.

But, funding for the AAP was terminated in June 1980. At present time funding to complete the study does not seem likely.

Massachusetts

The upper Housatonic River Basin occupies 530 square miles in Berkshire County, Massachusetts and a small part of Columbia County in New York. The basin is underlain by pitted and faulted carbonate rock with some lenses and outcrops of foliated metamorphic rock. The highlands at the west border are composed of schist and those to the east of gneiss. The bedrock tf the basin is mantled by glacial drift with till in the upland areas and stratified drift found primarily in the valleys of the Housatonic River and its tributaries.

The average annual precipitation over the basin measures 46 inches and is distributed rather evenly throughout the year. This amount of precipitation supplies 420 billion gallons of water per year to the basin. Hydrologic studies show that approximately 47 percent of this precipitation is evaporated and 53 precent becomes runoff. The annual water budget of the basin, a quantitative estimate of the relationship between precipitation, evapotranspiration and runoff, can be expressed as:

420 billion gallons of precipitation = 200 billion gallons of evapotranspiration and 220 billion gallons of runoff.

Supplies of groundwater are found in solution cavities in the bedrock and in the unconsolidated sediments of glacial origin. However, reliable estimates of the amount of groundwater in solution cavities are impossible to determine without extensive and expensive drilling procedures.

The unconsolidated sediments of the area are chiefly of glacial origin but also include some lacustrine, fluvial and swamp deposits of recent age. These recent deposits are generally fine grained and too impermeable to serve as sources of substantial groundwater supply. Till, a sediment of glacial origin consisting of poorly sorted clays, silts, sand and cobbles, is found as a discontinous mantle over bedrock hills and as elongate drumlin hills. Till deposits range in thickness from 0 to 90 feet and because of their low transmissivity are not considered useful as sources for municipal supplies. Stratified drift of glacio-fluvial and glacio-lacustrine origin occur in the valley bottoms and against lower slopes of the valley walls. These drift deposits range in thickness from zero to 240 feet and yield water to wells in amounts ranging from less than 1 gpm (gallons per minute) to 1500 gpm. It is only the coarser grained stratified drift deposits that can store and supply sufficient groundwater to serve as a source of municipal supply wells.

Extensive mapping, field investigation and test pumping are required to accurately determine the location and sustained yield of aquifers that could support municipal supply wells. Information gained from careful field reconnaissance and investigation can, however, be very useful in locating a deposit of stratified drift, which has a high potential for substantial yields of groundwater. Several of these high potential aquifers have been located in the Massachusetts portion of the Housatonic Basin. The potential yield of an aquifer is determined in part from the size of its recharge area. The term recharge area is defined here as that area from which precipitation or other source of water may infiltrate to and become part of the groundwater supply. In the study area the term "primary recharge area" has been applied to those areas of ground surface that transmit water to the aquifer at much greater than normal rates. The remaining surfaces transmitting water to the aquifer make up the "secondary recharge area" and include those areas having a significant soil mantle, with subsurface drainage toward the aquifer.

Previous Work

Much of the published information concerning the groundwater supply and distribution in the upper Housatonic Valley in Massachusetts is summarized in:

Berkshire County Regional Planning Commission, 1978, "Water Quality Management Plan for the Upper Housatonic River Final Plan/Environmental Impact Statement"

Other reports and studies concerned with the groundwater in the study area include:

Berkshire County Regional Planning Commission, 1972, Water Supply Alternatives - Pittsfield, Massachusetts, prepared by Curran Associates, Northampton, Massachusetts.

Berkshire County Regional Planning Commission, 1975, Alternative Future Sources of Water Supply - Great Barrington Fire District, prepared by Curran Associates, Northampton, Massachusetts.

Geraghty and Miller, Inc., 1972, "Memorandum" Review of Groundwater Conditions in Lenox, Massschusetts Area, contained within Studies and Reports Relative to the Impact of a Reservoir in Pleasant Valley Wildlife Sanctuary and the Feasibility of Wells as a Source of Water for the Town of Lenox, Masschusetts Audubon Society, Lincoln, Massachusetts.

Gilbert Associates, 1974, Study and Report on Groundwater Investigations for the Board of Water Commissioners, Pittsfield, Massachusetts, New England Office, Springfield, Massachusetts, W.O. No. 067019-000.

Metcalf and Eddy, Engineers, 1966, Report to the Board of Water Commissioners, Pittsfield, Massachusetts, upon Groundwater Investigation, Boston, Mass.

Motts, Ward S., 1972, "Ground Water Investigation in the Lenox-Lee Area," contained with Studies and Reports Relative to the Impact of a Reservoir in Pleasant Valley Wildlife Sanctuary and the Feasibility of Wells as a Source of Water for the Town of Lenox, Massachusetts Audubon Society, Lincoln, Massachusetts.

Motts, Ward S., 1981, The Potentiality of Groundwater as a Water Supply Alternative for Pittsfield, Massachusetts.

Norvitch, Ralph F. and Mary E.S. Lamb, 1966, Massachusetts Basic Data Report No. 9 Ground Water Series - Housatonic River Basin, prepared in cooperation with the Commonwealth of Massachusetts, Water Resources Commission.

Norvitch, Ralph F., 1966, Ground Water Favorability Map of the Housatonic River Basin, Massachusetts, prepared in cooperation with the Department of Interior, U.S. Geological Survey and the County of Berkshire, Massachusetts.

Norvitch, R.F., et al, 1968, Hydrology and Water Resources of the Housatonic River Basin, Massachusetts, U.S. Geological Survey Hydrologic Investigations Atlas HA-281.

Tighe and Bond, Consulting Engineers, 1976, Easthampton, Mass., "Report on Groundwater Exploration in Dalton, Massachusetts.

Whitmans and Howard, Inc., Boston, Mass., 1969, "Report Relative to Water System Improvements for Lenox, Massachusetts."

The geologic and hydrogeologic investigatiosn cited above have resulted in the identification and delineation of several aquifers in the study area. Plate B-4 in the Plan Formulation Appendix shows the approximate location of the important aquifers in the study area.

The Berkshire County, Regional Planning Commission has rated the aquifers as follows:

AA - current or planned municipal water supply

A - high potential as identified by various workers

B - possible domestic supply

Secum Brook	A
Daniels Brook	A
Town Brook	AA
Dalton	A
Vincent Farm-Brattle Brook	AA
South Pittsfield	A
Woods Pond	AA
Lenoxdale	AA
Greenwater Brook	B
Glendale	AA
VanDeusenville	AA
Lake Buel	A
Loom Brook	A

Site Descriptions

Thirteen aquifers sites have been identified in the study area as having potential for municipal water supply. Each of these thirteen sites will be described in this report. The description will include the known hydrogeologic setting, estimates of the potential yield of the aquifer and an explanation of how that estimate was derived, and a discussion of further work needed to increase the confidence level of the yield estimates.

Approximations of the transmissivity of the various aquifers were necessary in order to arrive at estimates of the groundwater yields from the sites. Detailed pumping tests are necessary to accurately determine the transmissivity of a give aquifer. Pump tests are out of the scope of this study so the transmissivity values had to be estimated from other hydrogeologic parameters such as lithology and saturated thickness.

Induced infiltration is a process by which the yield of certain wells can be increased. The additional yield is however no more than a transfer of water from streams and ponds to the gournd and must be viewed as such. If too much water is induced to infiltrate to an aquifer, the surface body supplying the water will reach a condition of critically low flow, which creates a negative environmental impact. Any use of induced infiltration must be judicious and take into consideration the necessity of maintaining sufficient amounts of water in surface streams and ponds in the local area.

The Town Brook aquifer is located in the town of Lanesborough. Investigation by Gilbert Associates, Norvitch et al and records of several wells indicate that in places the stratified drift is 150 feet thick and that there is 100 feet of saturated thickness. In at least one location current pumpage from the aquifer is 2 mgd from two wells in Lanesborough.

The Town Brook aquifer occupies 390 acres of primary recharge area and 4215 acres of secondary recharge area. Town Brook flows through most of the length of the aquifer and is a potential source of induced infiltration.

Four wells, properly constructed and located in this aquifer could produce 1 mgd each for a total aquifer yield of 4 mgd provided induced infiltration from Town Brook was employed. If considerations dictated that induced infiltration was not appropriate that the maximum safe sustained yield of the aquifer would probably not exceed 2.8 mgd.

The confidence level of this estimate is low. Data from seismic investigation, and/or pump test are necessary to raise the confidence level. Existing reports indicate no current water quality problems.

The Secum Brook aquifer is an irregularly shaped area just northwest of Pontoosuc Lake. A report by Metcalf & Eddy in 1966 concluded, on the basis of field investigation, well logs and pump tests that certain parts of the aquifer appeared to be too impermeable to support municipal supplies.

The Secum Brook aquifer is fed by a primary recharge area of 287 acres and a secondary recharge area of 4002 acres. Two properly constructed wells in an aquifer would probably supply .5 mgd each for a total aquifer yield of 1 mgd. The confidence level of this estimate is low; much more subsurface investigation is needed to increase the reliability of the estimate. Existing reports and field reconnaissance indicate no serious water quality problems.

Daniels Brook aquifer is located approximately one half mile southwest of Secum Brook and just north of Lake Onota. It lies on the boundary between Pittsfield and Lanesborough, northeast of the urbanized area of Pittsfield. Daniels Brook flows through the site.

The primary recharge area of the aquifer consists of 276 acres and the secondary recharge area is 2557 acres.

It is estimated that four wells in this aquifer could produce 80 gpm each for a total of 0.5 mgd from the aquifer.

The confidence level for this aquifer is very low. Much more field investigation and pump testing must be performed in order to increase the reliability of the estimates.

Existing reports and field reconnaissance show no outstanding water quality problems.

The Dalton aquifer is located in the west central part of Dalton. The area is crossed in part by Walker Brook and lies adjacent to the East Branch of the Housatonic River.

Tighe and Bond (1976) performed some seismic field investigation and pump testing. Records of several wells are available. A report by Gilbert (1974 page 18) suggests that 5 mgd are being pumped by industrial wells from the aquifer. This pumpage is generally in agreement with that mentioned by the USGS Basic data report by Norvitch et. al. in 1966.

The Dalton aquifer consists of 1115 acres of primary recharge and 3180 acres of secondary recharge.

Four wells properly constructed and properly spaced could possibly supply up to 0.3 mgd each for a total of 1.2 mgd.

The confidence level of this estimate is fair. A significant amount of pump tests, field work and seismic work has been done. The work should be updated to take into account changes in land use and any other wells that have been drilled. It is extremely important to determine how much water is being used by industry. If the Gilbert report is true and 5 mgd are still being removed from the aquifer then the amount currently estimated as being available from the site will have to be reconsidered.

Water quality problems of excess Fe, Mg and hardness have been reported. A landfill is reported in the aquifer.

Vincent Farm-Brattle Brook aquifer is located in Pittsfield on the eastern margin of the urbanized areas of the city. Field investigations have shown that there are two high yield areas in the site. The aquifer is crossed by Brattle Brook, which drains to the East Branch of the Housatonic River, and flows along the north side of the aquifer.

A substantial amount of study has been done on the area. Curran Associates in 1972, Gilbert in 1974 and Metcalf and Eddy 1977 all have made contributions. Field reconnaissance, study of well logs, pump tests and seismic investigations have been performed. Available information indicates little or no current pumpage from the aquifer.

The primary recharge area occupies 870 acres and the secondary recharge area 1220 acres. Significant potential exists for substantial amounts of induced infiltration from the Housatonic River. Some reports estimate up to 4-6 mgd can be gained from induced infiltration.

It is estimated that four properly constructed wells in the Vincent Farms area would yield 0.9 mgd each or 3.6 mgd for a total. Three wells in the Brattle Brook area would yield 0.6 mgd each or 1.8 mgd. Thus the entire aquifer is estimated to have a total sustained yield of 5.4 mgd. Assuming that the estimate of water supplied by precipitation infiltration is approximately correct then it must be concluded that in order to maintain a sustained yield of 5.4 mgd without premanently lowering the water table, a significant amount of water must be supplied to the aquifer by induced infiltration. This could cause quality problems, whereas the Housatonic River is presently contaminated with PCB's.

The estimates of high yield from the Vincent Farm aquifer is applied with a high degree of confidence. A determination of the exact yield can not be made without more precise study and investigation, but most probably the area is capable of yielding several millions of gallons a day on a safe-sustained basis.

The South Pittsfield aquifer is located on the west bank of the Housatonic River and borders on the south side of the Pittsfield urban area. A large sewage treatment plant is located at the southern end of the site.

Geohydrologic investigations of the site consisting of field reconnaissance, examination of well logs and pump tests are discussed in the Curran Report (1972). No figures for current pumpage are given in the existing reports.

The primary recharge area of the South Pittsfield aquifer consists of 525 acres and the secondary recharge area of 172 acres.

It is estimated that four properly constructed wells in this aquifer could yield approximately 0.9 mgd each or a total of 3.5 mgd for the entire aquifer. This estimate agrees very closely with that proposed by Curran Associates in 1972. This sustained yield apparently can not be supplied by precipitation alone and must depend on significant induced infiltration from the Housatonic River.

The estimate of 3.5 mgd of sustained yield should be given a confidence rating of medium. Investigations show the area to have high potential but the aquifer needs more testing and development to warrant a more reliable estimate.

Existing reports note no significant water quality problems but the presence of the sewage treatment facility at the south end of the aquifer is an indicator of potential concern. The aquifer is immediately downstream from the urban area of Pittsfield and this might be contaminated now or in the future with PCB's.

The Wood's Pond aquifer is located adjacent to the Housatonic River just north of Wood's Pond in the town of Lenox. No streams cross the site but a quiet stretch of the Housatonic lies approximately 1000 feet to the east.

The area has been investigated by Whitman Howard in 1969. Motts (1972) also referred to the site. No reliable data on the thickness of the stratified drift was included in either of these reports. Existing information on current pumping is lacking but all indications suggest little or no water is being taken from the aquifer at present.

The primary recharge area consists of 69 acres and the secondary recharge area of 1259 acres.

The question of yields may not be relevant, however, since a USGS report by Gay (1980) discusses the detection of Polychlorinated Biphenyl (PCB) residues in water pumped from wells around Wood's Pond. The Massachusetts DEQE has notified communities that it will no longer grant permits for publc water supply wells adjacent to the Housatonic River. The USGS and the Massachusetts Division of Water Pollution Control are investigating the entire question of the potential hazards to groundwater supply resulting from pumping adjacent to streams which are contaminated with PCB's.

The Lenoxdale aquifer is located adjacent to the Housatonic River and just south of Wood's Pond in the town of Lee. No stream crosses the site but the Housatonic River flows along the west border of the aquifer.

The area has been investigated by Geraghty and Miller, 1972, Motts in 1972 and more recently by the USGS in 1979.

Existing production of industrial wells (The Schweitzer Co.) is estimated at 1.5 mgd.

The primary recharge area of the aquifer consists of 364 acres and the secondary recharge area comprises 393 acres.

Two properly constructed wells in the aquifer could possibly yield 1.7 mgd each or if conditions warranted 4 smaller wells could yield 0.9 mgd each for a total of 3.5 mgd additional yield for the aquifer. This amount when added to the estimated 1.5 mgd withdrawal from industry wells, indicates a total potential yield from the aquifer of 5.0 mgd. The confidence level of this estimate is high in that it is supported by extensive field investigation and pump tests.

Prior to the areawide concern about PCB's the water quality of this aquifer was considered high. The USGS report by Gay (discussed under the Wood's Pond section of this report) places the water quality question in doubt. This is critical to any estimate of yield from the Lenoxdale aquifer because "natural" recharge from precipitation will supply only about 0.7 mgd to the groundwater reservoir. If a total of 5.0 mgd were to be withdrawn from the aquifer (without permanently lowering the water table) then 4.3 mgd of that amount would have to come from induced infiltration of Housatonic River water.

The Greenwater Brook aquifer is elongate in shape and located along Greenwater Brook, a tributary of the Housatonic River that drains Greenwater Pond.

The primary recharge area of the Greenwater Brook aquifer makes up 724 acres and the secondary recharge area consists of 12,500 acres.

Five wells properly constructed and spaced along this aquifer could possibly yield 280 gpm each for a total of 2.0 mgd for the aquifer as a whole.

Because little is known about the hydrogeologic properties of the Greenwater Brook aquifer, the confidence level in any quantitative estimate must be considered low.

No water quality information is available. The danger from PCB contamination is most probably very low except for wells drilled adjacent to the Housatonic River. Because the Massachusetts Turnpike runs next to a significant part of aquifer the potential for sodium contamination is present.

The VanDeusenville aquifer is locaed immediately adjacent to the Housatonic River in the northern part of the town of Great Barrington.

The site was investigated in 1975 by Curran Assosiates. The primary recharge area of the aquifer is 260 acres and the secondary recharge area is 285 acres. There is excellent potential for sizable amounts of water to be induced from infiltration from the Housatonic River.

Three properly constructed wells in this aquifer could yield 0.8 mgd each or a total of 2.5 mgd for the aquifer.

Because pump test data and other specific details of the aquifer are lacking, the confidence level of any estimate for this aquifer is low.

No information on water quality of this aquifer is available. The potential for contamination by PCB's is present in that the aquifer is downstream from the urban area of Pittsfield and is immediately downstream from a ponded section of the river which may serve as a repository for PCB rich sediments. Any future consideration of the development of the VanDeusenville aquifer must include a study of PCB contamination because any pumpage from the site in excess of 0.5 mgd would have to come from induced infiltration of the Housatonic River.

The Glendale aquifer is located along the Housatonic River near the village of Glendale in the southern part of the town of Stockbridge.

The primary recharge area consists of 177 acres and the secondary recharge area of 95 acres. There exists good potential for induced infiltration from the Housatonic River.

It is estimated that two properly constructed wells in such an aquifer could produce 0.4 mgd each for a total of 0.8 mgd.

The lack of specific information rates the confidence level of this estimate as low. Much more detailed investigation is necessary to improve the reliability of an estimate.

No information on water quality is available. The conern over PCB's discussed for other sites in the study area, should also be considered here since over half of the estimated yield would be supplied by induced infiltration of the Housatonic River.

The Lake Buel aquifer is located on the west side of Lake Buel and overlaps the boundary between Great Barrington and Monterey.

The USGS basic data report (Norvitch et al 1966) lists two public water supply wells to depths of 35 feet drilled in the east end of the site. No current pumping figures are available. The primary recharge area is 481 acres and the secondary recharge area is 727 acres. There is a strong possibility of induced infiltration from Lake Buel. The large recharge area and the possible hydrologic connection with Lake Buel are the principle reasons why this area is considered as exhibiting potential for municipal water supply. Three properly constructed wells could yield 0.3 mgd each for a total aquifer yield of 0.9 mgd.

In that these yields were based entirely upon assumptions, the confidence in their reliability is very low. Further drilling seismic, and pump tests would be required to upgrade the reliability of any future estimates. No data on water quality is available.

The Loom Brook aquifer is a small area located adjacent to Lake Garfield in the town of Monterey. No specific geohydrologic information is available for this site other than the delineation of its recharge areas. The primary recharge area of 80 acres with the secondary recharge area of 1908 acres could supply approximately 1.0 mgd to the aquifer from infiltration of local precipitation.

Because no information exists concerning the properties of the aquifer, no attempt will be made to estimate yields.

DESIGN & COSTS

Methodology for Areawide Planning Studies (MAPS)

The MAPS computer program is a tool developed by the Environmental Laboratory of the U.S. Army Engineer Waterways Experimental Station to assist Corps personnel, primarily engineers, in screening alternative facility plans. While it has applications in other areas, it has primarily been used in water supply studies. The MAPS program has been used to perform preliminary design and cost estimates for screening water supply alternatives in the Housatonic Urban Study. These cost estimates are for the purpose of comparing alternatives and are not suitable for use by utilities or municipalities as engineering estimates of individual projects.

The cost estimating methods used in MAPS are designed to produce reasonably accurate estimates for a large number of alternatives, given the limited amount of data usually available in a planning study. The accuracy of the estimates depends on how closely the facility under consideration resembles the facilities or components used in developing the cost estimating procedures. The methodologies and cost data used by the program have been reviewed and compared to actual bid prices and construction cost estimates of projects in the area and, therefore, have been found to be sufficiently accurate for stage 2 planning studies.

The main design and cost routines used to evaluate the alternatives in this study are transmission mains, pump stations, treatment plants, wellfields and dams. A description of the input and analysis of the cost data for each routine is presented in the following section.

TRANSMISSION MAINS

The design and cost of transmission mains are based on the data shown in Table C-9. The MAPS program calculates the diameter, required head and all associated costs from this data. Costs determined by the program include construction, overhead and operation and maintenance.

WATER TREATMENT PLANTS

The water treatment plant design module in MAPS can calculate planning level construction, overhead, operation and maintenance, and average annual costs of water treatment plants based on the unit processes used and the design and operation specifications for these processes. However, MAPS water treatment plant costs were found to be extremely low and therefore were not used to develop treatment costs for this study.

TABLE C-9

TRANSMISSION MAIN INPUT

Description	Data or Source of Data
Length	USGS Quad, Scale 1: 24,000
Initial Elevation	USGS Quad, Scale 1: 24,000
Final Elevation	USGS Quad, Scale 1: 24,000
Peak Elevation	USGS Quad, Scale 1: 24,000
Final Pressure	50 ft.
Depth of Cover	5 ft.
Rock Excavation	20%
Ductile Iron Pipe	For Diameters 4" to 48"
Reinforced Concrete Pipe	For Diameters 54" to 120"
Bends or Elbows	12 per mile
Gate Valves	3 per mile
Dry Soil Conditions	Assumed throughout

TABLE C-10

DAM MODULE INPUT

Description	Data or Source of Data
Embankment Description	(See Plate A-1)
Drainage Area	S.C.S. Data
Reservoir Storage	S.C.S. Data
Reservoir Surface Area	S.C.S. Data
Spillway design flow	Max. Probable flood curves
Outlet Design Flow	Varies Based on Reservoir Yield
Relocations	Field Investigations

PUMP STATIONS

The design and cost of pump stations are based on the data obtained from the transmission main routine. The MAPS program, through a pipeline design module, will cost and design several combinations of pipe diameter and pump stations for a length of pipe. The user is then able to select the optimal diameter and station size from the data. Costs associated with pump stations include; construction, overhead and operation and maintenance.

DAMS

The MAPS dam module calculates the cost for a dam and reservoir given a description of the dam and reservoir, which includes the existing ground elevations at the dam site. A typical dam section is shown in Plate C-6, other data used in the cost and design routine is shown in Table C-10. Costs determined by the program include; construction, overhead, and operation and maintenance.

The cost analysis used to evaluate each alternative is based on a 50 year study period beginning in 1980 and extending to 2030. July 1981 price levels and an interest rate of 7.375% is used throughout the study.

Capital costs are broken down into overhead and construction costs. Overhead costs include engineering, interest during construction, legal, fiscal and administrative costs. Construction costs include materials, equipment, structure, and other construction items specific to the facility being built. Costs for dikes are not included in the total construction costs.

WELLFIELDS

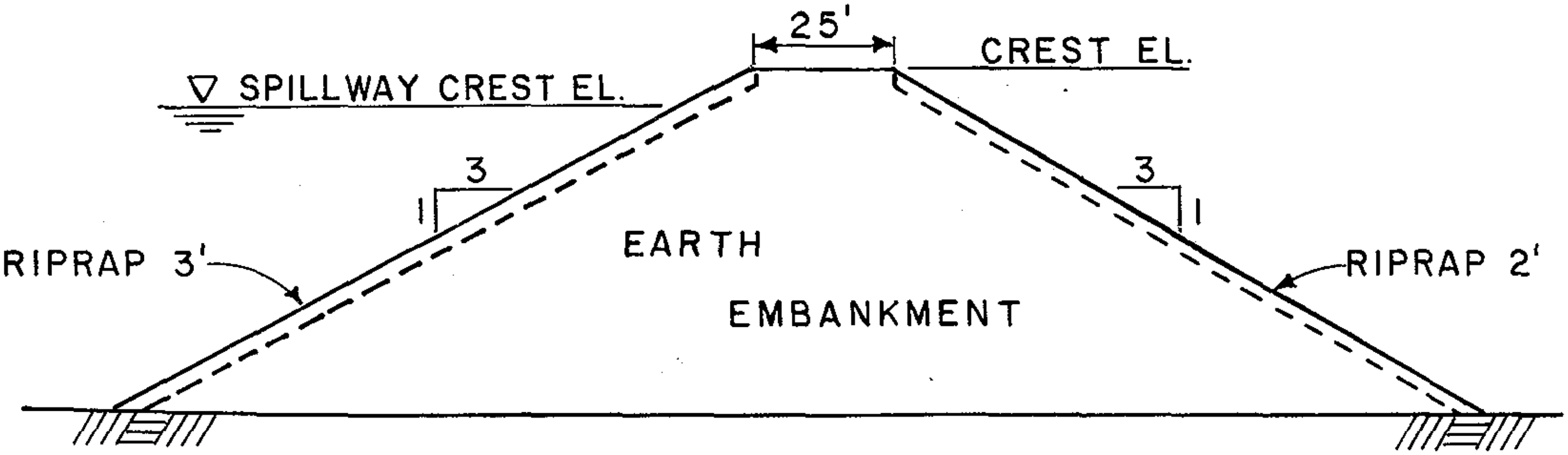
The MAPS wellfield module determines the costs for one or more wells installed in a wellfield. Wells within the wellfield are assumed to have similar properties such as: each well (a) delivers roughly the same flow, (b) is drilled to approximately the same depth, (c) draws from the same aquifer, (d) has the same design life, and (e) is located in the same geographical area.

Costs determined by the program include; construction, overhead and operation and maintenance.

Flood Proofing

Variable cost data has not been prepared for:

1. Utility Cells or Rooms
2. Closures



TYPICAL DAM SECTION

HOUSATONIC RIVER BASIN
URBAN STUDY

TYPICAL DAM SECTION

NOT TO SCALE

PLATE C-6

Costs of utility cells and rooms are believed to be fairly uniform, regardless of level of protection type of structure.

The cost of closures is dependent on the level of protection and the number of openings at a structure. Because of the variability of these factors, cost estimates for closures are most reliable when prepared for individual structures, based primarily on the square footage of openings susceptible to flooding. The cost of closure per square foot shown below was developed for other Corps studies and updated to July 1981 price levels.

Closures

Cost	\$60/SF
Contingencies (2%)	12
	\$72
Engineering and Design (15%)	9.8
Supervision and Administration (10%)	7.2
	\$89.0

Say \$90/SF, installed

Cost Curves have been developed in previous Corps studies for:

1. Small Walls and Levees
2. Raising Structures
3. Relocation of Homes

These cost curves demonstrate the variability of flood proofing costs dependent on level of protection and/or type of structure.

Generalized costs for small walls and levees are primarily dependent on the level of protection provided.

Costs per linear foot for a concrete I-Type floodwall are presented below. Initial costs were obtained from a curve developed from information obtained from the Corps studies and updated to July 1981 price levels. The final cost per linear foot includes: contingencies (20%), engineering and design (15%), supervision and administration (10%), and all appurtenant works (walls typically account for 60% of total job).

Concrete Walls

Wall Height (feet)	Construction Cost	Contingencies E & D, S & A	Total Cost
1	$410	$238	$648
2	417	242	659
3	445	258	703
4	480	278	758
5	515	299	814
6	572	332	904
7	628	364	992
8	685	397	1,082
9	748	434	1,182
10	812	471	1,283

Costs per linear foot for a levee are presented below. These costs were also developed from information from other studies. The final cost per linear foot includes: update to July 1981 price levels contingencies (20%), engineering and design (15%) and supervision and administration (10%).

Levees

Levee Height (feet)	Construction Cost	Contingencies E & D, S & A	Total Cost
3	$ 89	$ 52	$141
5	136	80	216
7	180	105	285
9	232	136	368
11	283	166	449
13	343	201	544
15	401	234	635

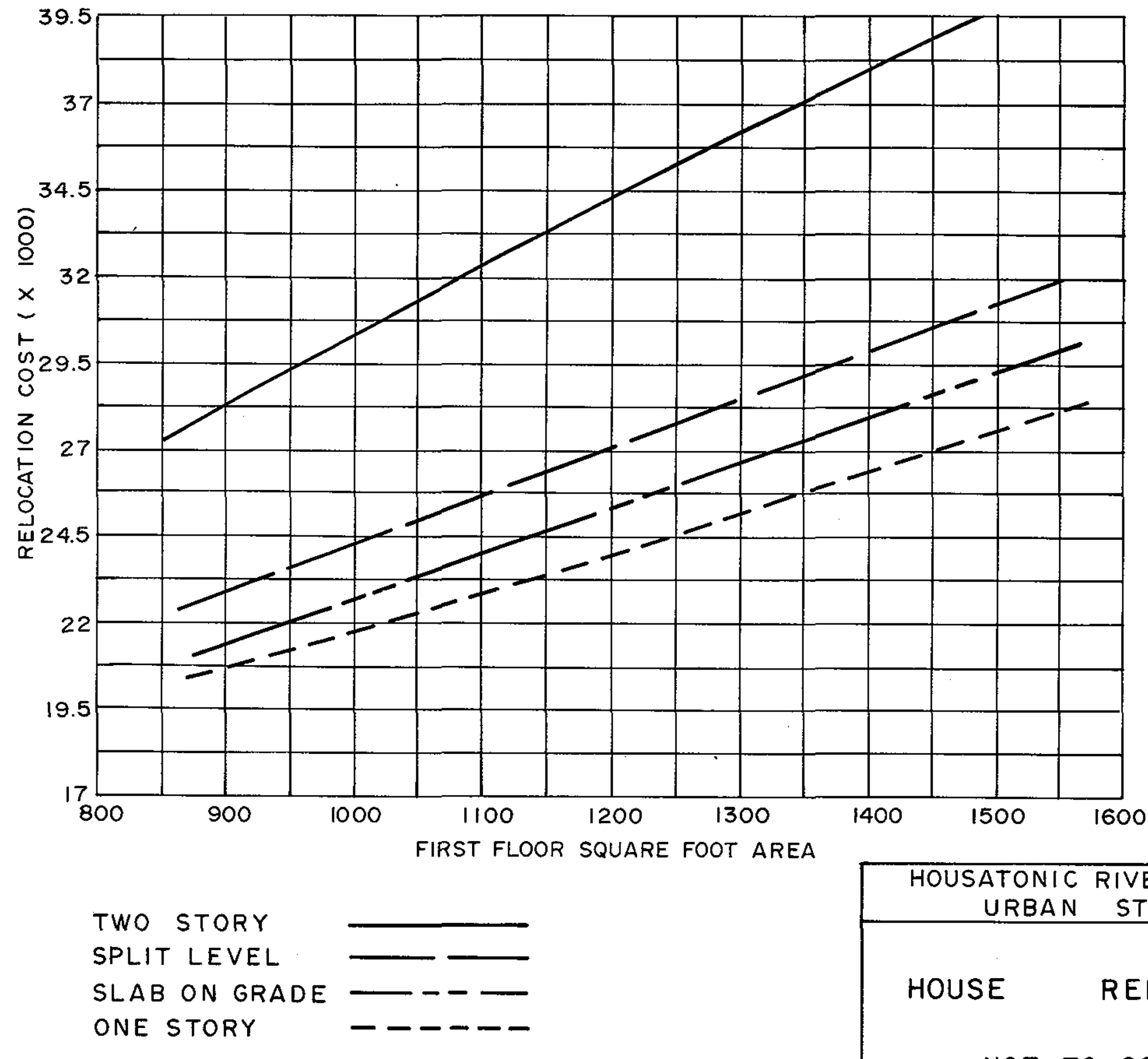
Generalized costs for raising structures are dependent on the type of structure and the height of raising. Costs for raising various residences are presented below. The costs were obtained from curves developed by other studies and updated to July 1981 price levels. Costs of raising include: raising, new foundation, landscaping and relocation of utilities. The costs shown below assume concrete or concrete block basements.

Raising

Elevation Raised	Cape	Ranch	Colonial	2-Family
1.33	$12,490	$16,190	$17,200	$17,570
2.00	14,110	18,190	18,710	19,300
2.66	15,720	20,200	20,230	21,030
3.33	17,340	22,200	21,740	22,760
4.00	19,420	24,350	23,740	24,880
4.66	21,510	26,510	25,740	27,010
5.33	23,590	28,660	27,740	29,130
6.00	24,460	29,700	28,690	30,030
6.66	25,320	30,750	29,640	30,940
7.33	26,190	31,790	30,590	31,840
8.00	27,050	32,830	31,540	32,740
8.66	27,910	33,870	32,490	33,640
9.33	28,770	34,910	33,440	34,540
10.00	29,630	35,950	34,390	35,440

Generalized costs for house relocation are dependent on the type of structure (assuming relocation is within 10 miles). The curve on Plate C-7 presents the costs of house relocation.

It appears that the flood proofing costs used in this report, while generalized, are consistent with current NED project estimates and/or actual flood proofing costs incurred in Revere, Massachusetts. It is concluded that the costs presented in this study represent the best possible estimate for this stage in the planning effort.



HOUSATONIC RIVER BASIN
URBAN STUDY

HOUSE RELOCATION

NOT TO SCALE

PLATE C-7

APPENDIX D

REVIEW COMMENTS

APPENDIX D

TABLE OF CONTENTS

APPENDIX D - REVIEW COMMENTS

INTRODUCTION

The Public Review Draft Feasibility Report was released on 19 July 1982 for review and comment. Copies of the Draft Feasibility Report were sent to all 77 communities as well as various Federal, State, regional and local agencies.

The following text of this Appendix contains all the letters received submitting comments on the Draft Feasibility Report. In most cases the report text was adjusted to reflect these comments. Some of the comments did not warrant changes in the text, just an explanation of terminology or methods used in the report. Following the letters is a response section answering any questions or clarifying issues where needed.

United States
Department of
Agriculture

Soil
Conservation
Service

451 West Street
Amherst, Massachusetts 01002
Tel. (413) 256-0441

July 30, 1982

Division Engineer
New England Division
U S Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Sir:

Re: NEDPL - BU - Housatonic Urban Study, Feasibility Draft Report

We have reviewed the subject report and offer the following comments and suggestions:

1. The legend on Plate 3 does not indicate the difference between shaded and unshaded towns.

2. On page 36, paragraphs 4 and 5, water supply options for Lee and Lenox are described. Cost figures appear to be quoted from the Washington Mountain Brook EIS (page E-G). One clarification is needed. The cost figures on page E-G of the EIS reflect the cost of a single purpose water supply development at these sites and are not SCS project costs. Please delete the reference to: "SCS Washington Mountain Brook project" at the beginning of the fourth paragraph.

3. Pages 41-43 discuss Pittsfield water supply studies. The Metcalf and Eddy study of 1982 is not included.

4. Page 15, 3rd paragraph: In the last sentence the word erections should be changed to excrements.

5. Page 69, the recommendations are written in the first person. "Whom" is not identified. This section is rather abrupt and gives minimal rationale for the recommendations.

The opportunity to review and comment is appreciated.

Sincerely,

Willie L. Riffin
Acting For
SHERMAN L. LEWIS
State Conservationist

cc:
M. Kolman/F. Resides

OFFICE OF THE DIRECTOR

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs
Department of Environmental Management
Division of Water Resources
Leverett Saltonstall Building, Government Center
100 Cambridge Street, Boston 02202

August 2, 1982

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Attention: Mr. Robert Martin

Dear Sir:

With regard to the Public Review Draft Feasibility Report for The Housatonic Urban Study, we are pleased to submit the following comments:

1.) Page 7, 2nd paragraph - There are 16 public water supply agencies shown in Table 2. We also list the following not shown:

a.) In Stockbridge - Mahkeenac Water Works Corporation.

b.) In Lanesboro - Berkshire Village Cooperative Water Works.

c.) In Dalton - New Junction Water Company.

We are enclosing our preliminary work sheets on these water systems together with the Housatonic Basin pages from our booklet Massachusetts Water Supply Agenices.

2.) Page 9, 1st paragraph - We feel that 180 people/mi.^{2} is low for Massachusetts population density. We obtained 187 for the watershed using the 1980 census.

3.) Page 12, Table 2 cont. - With regard to the deficit in Lee,Goose Pond is on standby with a safe yield of 0.3 mgd. If you wanted to add this to the safe yield it would reduce the deficit somewhat. With regard to Monterey Water Company, we list their safe yield now at .091 since they have added a groundwater source. Is your 0.21 safe yield correct?

-continued-

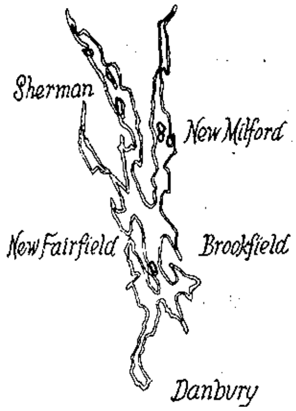
4.) Page 9, 4th paragraph - In Massachusetts, the one half gallon/capita/day figure may be high particularly if the City of Pittsfield gets a water supply improvement program underway.

We hope that this is of assistance.

Sincerely yours,

Charles F. Kennedy
Director & Chief Engineer

CFK/WFB/sfc
Encl.



P.O. BOX 37
SHERMAN, CONNECTICUT
06784
Chairman, - Hartley W. Howard
(203) 354-6928

CANDLEWOOD LAKE AUTHORITY
CONNECTICUT

August 5, 1982

Division Engineer
New England Division
US Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Sir,

We have had the opportunity to read that portion of the Draft Report of the Housatonic Basin Study dealing with Lake Candlewood and would appreciate receiving a copy of the full report for our files.

In response to the request for comments on the draft, we direct your attention to the two statements following;

p.26 "The Danbury Water Department presently has a pipeline interconnecting the lake with their system. Candlewood Lake was used by the water department as an emergency supply source during the later part of the 1960's drought."

p.27 "...if Candlewood Lake were to be used by Danbury, it would only require the addition of a pump station and treatment facilities as the pipeline is already in place..."

The statement that the city of Danbury used water from Candlewood Lake as an emergency source in the 1960's is correct. This was accomplished as a temporary measure using borrowed pumps to force the water through agriculture pipes across the land of the Federal Correction Institute (FCI) to Margarie Reservoir. Following the drought, the pumps and piping were removed.

There is no existing pipeline from Candlewood to the Danbury water system.

Sincerely,

H. W. Howard

H. W. Howard, Chairman
Candlewood Lake Authority

cc/Jonathan Chew

STATE OF CONNECTICUT

OFFICE OF POLICY AND MANAGEMENT
COMPREHENSIVE PLANNING DIVISION

August 6, 1982

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

ATTENTION: Mr. Robert G. Martin

Dear Sir:

This is in response to your letter of July 19, 1982 affording this office the opportunity to review the "Public Review Draft Feasibility Report for the Housatonic Urban Study". I appreciate the opportunity to comment further on this important matter and offer the following by page:

i. par. 5: Does the count of 131 systems include those systems serving the south western part of Connecticut?

ii. par.'s 5, 6 & 7: We have in these paragraphs some potential semantical problems involving the words local, community and regional. By use of the term "local" does the Corps mean anything non-federal? If so, this is confusing to most readers and should be clarified as to whether one means state, regional and/or local or municipal. It also appears when the Corps uses the term "regional" they are thinking of truly large systems. We tend to think of regional in the context of Connecticut as possibly a somewhat lesser scale. For example, does the Corps view a possible expansion of Bridgeport hydraulic water usage as regional or not? Finally, an indication that solutions were evaluated on a "community-by-community basis" infers at least that no inter-municipal, district or regional solutions were found and that all matters can be resolved within the confines of an individual municipality. I doubt you mean this, but this is inferred.

iii. par. 4: There is an inference here that in the entire study area there are only 14 municipalities involved in the flood insurance program. Furthermore, the two mentioned not in the regular phase should be at least shown to be in the emergency phase.

1. par. 1: Appendix A should not be mentioned unless it is made a part of this report.

2.: Among state agencies it would seem appropriate to mention the Department of Public Utility Control and also in the paragraph on coordination. Coordination with the Western Connecticut Water Supply Council could also be mentioned.

Phone:
80 WASHINGTON STREET • HARTFORD, CT. ~~06115~~ 06106
An Equal Opportunity Employer

5. par. 3: There are five Connecticut planning regions within the original study area; there are two more Connecticut regions if one adds the southwestern area. Furthermore, there is no mention of the planning region in Massachusetts.

9. par. 3: I continue to feel that the paragraph heading "Without Project Conditions" will not be understood outside of Corps circles. This is also true for the fourth paragraph.

11.: I understand the Department of Public Utility Control will be writing to clarify or correct the names of some of the water utilities listed. You might want to consider an asterick (*) with regard to the Danbury 1980 deficit noting that steps have been taken to overcome this and with regard to Norwalk 2nd noting they can draw on water from Bridgeport Hydraulic. In previous correspondence with your office I had urged that there be a general discussion of the multitude of smaller water companies not, for example, listed on this page. This we do not believe has been done. There should be an indication on this page that there are far more utilities than those listed and there should be a general discussion concerning those utilities somewhere in the report.

15. par. 3: It might be more accurate to indicate the law relates to "surface" water supply sources. On the fourth line the appropriate section reference is 25-26a not 62a. The correct date for Public Health Code is 1980 and Water Quality Standards and Criteria is 1980. In copying a submittal from DEP there appears the possibility that a line was left out. On line 12 of paragraph 3 item 2) should end with "--entirely understood or predictable; 3) the public health implications for long term exposure to pollutants is not entirely known."

16. par. 3: Using the terms municipal and industrial in the same sentence may be confusing. Would it be better to say residential, commercial and industrial?

17. par. 1: There is reference to an appendix not part of this report.

19. par. 7: Is it not a bit strong to state that "advanced treatment techniques would be used to make the effluent safe for human consumption"?

21. par. 5: Same discussion regarding page ii. There is an inference here of no regional solutions.

22. par. 3: Would it not be well to note there is a cost involved in removing the existing discharges?

22. par. 5: Is there actually a basis for describing December through May as the "wet months" since precipitation is fairly consistent throughout the year in Connecticut. It might also be desirable to explain why "A maximum diversion of 11 mgd was evaluated".

24. par. 1: An impression is clearly given in the last sentence that far more can be achieved by the existing interconnects than I believe is possible.

26. par. 3: I have heard second hand that there is presently no pipeline interconnecting the Danbury system with Candlewood Lake.

26. par. 5: After a conversation with DHS staff, it appears to me there are real problems and questions concerning the last two sentences regarding recreation in this paragraph. I believe Ray Jarema of DHS will be in contact with you. If not, I urge you to make direct contact to him before finalizing this report.

27.: Prior to the last two paragraphs I urge insertion of a heading "Other" since these paragraphs are unrelated to the prior heading "Candlewood Lake".

28. on: There seems to be an inconsistency in discussing individual water utilities as to whether safe yield, population served and average daily consumption are discussed or not discussed.

28. par. 4: It would be more appropriate to note that Lake Kenosia has been added to the system than simply that it was recently studied.

30. par. 1: I believe the stated average day demand of 19.7 mgd is too high.

31. Table: Why was Bridgeport Hydraulic not listed?

33. par. 3: Does the cost for the Norwalk River Diversion include eliminating waste discharges from the river?

34. par. 3: Should there be mention of reported efforts to rehabilitate the rewalk well for Darien?

59. par. 1: I consider it unfortunate to indicate that the flood problem faced by residents does not appear to be serious when you go on to say that the effects of ice jams were not considered.

67.: The amount of space in the conclusions devoted to water supply vs. flood control seems out of balance.

69.: Again use of the term "local" may be confusing especially if regional solutions are ultimately determined to be needed in at least some instances.

Thank you for the opportunity to comment and to participate in other ways in the study. If there are any questions concerning this review, please feel free to contact me. I am assuming that any other state agency reviewers will send comments directly to you.

Sincerely,

Sidney Albertsen

Sidney Albertsen
Planning Analyst

SA:clm
cc: Fred Banach, DEP
Brian Emerick, DEP
Carolyn Gimbrone, DEP
Arba Roberts, DEP
Bob Smith, DEP
Horace Brown, OPM
Ray Jarema, DHS
Al Kelley, WCWSC
Pete Kosak, DPUC

CITY OF DANBURY, PUBLIC UTILITIES
155 DEER HILL AVENUE
DANBURY, CONN. 06810
TELEPHONE 797-4539

WILLIAM J. BUCKLEY JR., P.E.
SUPERINTENDENT OF PUBLIC UTILITES

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02254

RE: Housatonic Urban Study

Attention: NEDPL-BU

Dear Sir:

I have reviewed the draft feasibility report of the Housatonic River Basin Urban Study dated July 1982 and have the following comments:

1) Page 7, paragraph 1 under Water Supply: The report states that the 67 systems around Candlewood Lake "primarily supply water during the summer recreation season." Many of these supplies were originally set up as summer supplies, however, at the time I believe the majority supply water throughout the year. Perhaps less than a dozen are primarily summer use. It is generally recognized that all water companies produce more water in the summer.

2) Page 10, Paragraph 1 and 2: The deficits shown are inaccurate. The deficits shown are based on an existing safe yield for Danbury of 6.5 mgd which represents the combined safe yield of Margerie and West Lake only. We have the Kenosia and Osborne well fields which do not appear to be included. Additionally our Kenosia Diversion project referenced a number of times in the report, added 2.1 mgd to our safe yeild. Danbury's safe yield should be 8.6 mgd surface system; and 2.0 mgd ground water system. This adjustment effects many comments, etc. in the report.

3) Page 11, Adjust safe yield, and deficit for Danbury.

4) Page 15, Paragraph 3: I question the feasibility of eliminating sewage discharges from the Shepaug. In one instance I believe this would require a nine mile diversion. Is that economically feasible?

5) Page 15, Paragraph 3, last sentence the word after human is incorrect.

6) Page 26, Paragraph 2, This statement is incorrect. The Danbury Water Department does not have a pipe line connecting Candlewood Lake to Margerie Reservoir. In the 1960's a temporary overground line was placed.

7) Page 27, Paragraph 1, If Candlewood Lake were used Danbury would need a pump station and pipeline. No treatment facilities would be required as the water would be pumped into Margerie Reservoir and processed at that plant.

8) Page 28, Paragraph 1, Projected demands, and deficits must be adjusted as previously mentioned. Also we serve 40,000 people.

9) Page 28, Paragraph 2, Margerie would have to be raised 3 (Three) feet not eight (eight) feet.

10) Page 28, Other altenatives not mentioned are increasing the capacity of the Kenosia and Osborne Street well fields. These two projects could yield 3.0 mgd of safe yield.

Thank you for the opportunity of review of the draft report. Should you have any question or care to discuss this matter furthuer do not hesitate to contact me.

Sincerely,

William Buckley Jr.

William J. Buckley Jr.
Superintendent

WJB:vai

cc: J. Schweitzer
R. Jarema
J. Anderson DEP
Sid Albertson OPM

United States
Department of
Agriculture

Soil
Conservation
Service

Mansfield Professional Park
Storrs, Connecticut 06268

August 9, 1982

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Sir:

The following comments are in response to the Housatonic River Basin Urban Study draft report:

1. Page ii - Additional flood control measures within the basin, which have been constructed under PL-566, include five dams in the Blackberry River Watershed.

2. Pages iv and 67 - Other options for implementation programs are PL-566 (Watershed Protection and Flood Prevention Act) and the Resource Conservation and Development program. See enclosed sheet for brief program descriptions.

Thank you for the opportunity to comment on your draft report.

Sincerely,

Philip Christensen

Philip H. Christensen
State Conservationist

Enclosure

USDA Soil Conservation Service
Program Descriptions

PL-566

The Watershed Protection and Flood Prevention Act, Public Law 83-566 Stat. 666 authorizes "the Secretary of Agriculture to cooperate with states and local agencies in the planning and carrying out of works of improvement for soil conservation and for other purposes." It provides for technical and financial assistance by the Department through the Soil Conservation Service (SCS) to local organizations representing people living in small watersheds (less than 250,000 acres). The Act provides for a project-type approach to solving land, water, and related resource problems. Flood prevention is an eligible purpose for which SCS can pay 100 percent of the costs for planning studies, design, and construction of structural solutions while the local sponsoring organization is responsible for land rights, operations and maintenance. Nonstructural costs for implementation are divided 80 percent federal and 20 percent nonfederal.

RESOURCE CONSERVATION AND DEVELOPMENT

The Resource Conservation and Development (RC&D) Program was authorized by the Food and Agriculture Act of 1962. It expands opportunities for conservation districts, local units of government, and individuals to improve their communities in multicounty areas. The Program can assist them in enhancing their economic, environmental, and social well-being.
Flood prevention measures are planned and carried out where there is a need for reducing or preventing water damage from inundation of property, business and/or threatening the loss of life. Flood prevention is related to the control and disposal of surface water caused by either stream overflow or abnormally high direct precipitation. RC&D may provide up to 100 percent of construction costs.

SOUTH WESTERN REGIONAL PLANNING AGENCY
DARIEN GREENWICH NEW CANAAN NORWALK STAMFORD WESTON WESTPORT WILTON
213 LIBERTY SQ., EAST NORWALK, CONNECTICUT 06855-1029 866-5543

August 9, 1982

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Mr. Ignazio,

This will acknowledge your letter of July 19, 1982, enclosing a copy of the Feasibility Report draft of the Housatonic River Basin Urban Study, dated July 1982.

The South Western Regional Planning Agency was advised of the receipt of this report at its meeting on August 2, 1982, and I was authorized to make a staff commentary to you concerning its contents.

Also, on August 5, 1982, the report was discussed in greater detail at one of our Water Supply planning meetings, which was attended by representatives of several public and private water supply companies and districts, as well as other local and regional public officials.

My comments are as follows:

1. The period for comment which now ends August 13th should be extended into the early fall, to allow more thorough review by local, state, and regional bodies, including a newly-established state legislative task force on water supply policy. Such further review is even more important given the recommendation on page 69 by the Corps of Engineers: that the water supply portion of the Housatonic Urban Study be terminated.

2. While the alternatives cited in the report are of great interest, adequate comparison cannot be made unless operating costs and the cost of the water itself are also included in the analysis. Your report provides only capital cost information. We suggest that further analysis be done by the Corps of Engineers to provide a proper comparative basis for evaluation.

3. It should be understood that safe yield and average daily demand figures are dynamic in nature, and have changed in the two years since 1980. I am sure that more detailed information will be provided to you by the water companies involved.

4. Why was further consideration of the Cannondale Aquifer not pursued?

5. Were the service quality standard constraints to be eased, viable sources of water would be available.

6. It was suggested at the Water Supply Planning meeting that the presently planned 16-inch connection between the Norwalk Second Taxing District and the New Canaan Water Company be expanded to a 24-inch main that would be part of an ultimate through-route that would connect to the Stamford Water Company.

7. We suggest that the ownership of interconnecting pipes be jointly held, so that provision could be made for alternative combinations of water transfer.

There was general favorable comment with regard to the so-called Bridgeport Hydraulic Company interconnection described on page 24. However, it must be emphasized that more cost information is necessary prior to any expression of clear preference fo any single alternative.

We appreciate this opportunity to comment on this very important report.

Very truly yours,

Richard C. Carpenter
by spd

Richard C. Carpenter
Executive Director

RCC/spd

cc: Sarah L. Kennerly, Agency Chairman
Barbara Girdler, Agency Representative, Greenwich

P.S. - Please note that as of June 1, 1982, the South Western Regional Planning Agency's offices have moved: from 137 Rowayton Avenue in Rowayton to 213 Liberty Square, East Norwalk, CT 06855-1029.

Stamford Water Company
103 Summer Street • P. O. Box 1196
Stamford, Connecticut 06904

Tel. (203) 324-3163

August 11, 1982

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Re: Housatonic River Basin Urban Study
Public Review Draft Feasibility Report

Gentlemen:

I appreciate the patient effort expended by Corps personnel in developing the water supply section of the subject report, especially that of the Project Manager, Mr. Robert Martin. I believe the work to be an important first step in being able to develop regional water supply plans for Connecticut.

Regarding the Stamford Water Company numbers in TABLE 2, page 31, you ought to be aware of the following corrections and/or changes. We currently estimate our safe yield to be 17.5 mgd and our average daily sendout for the 12 months ended June 30, 1982 was 14.28 mgd. This included the sale of approximately 1.0 mgd to the Noroton District.

Based upon the projections of both the Stamford Planning Board and the State of Connecticut population growth in Stamford should cause an annual increment in water sales of approximately 0.1 mgd until the year 2030. If this is true then our 10% margin of supply over demand (15.9 mgd) will not be reached until 1998.

In addition, we are suggesting that the Noroton District obtain all of its supply from Norwalk. Then we would not reach our 10% margin of supply over demand until 2008.

However, in order to meet Stamford's water supply requirements in 2030, additional water will have to be brought into the Southwestern area. This will probably be done by constructing transmission mains and strengthening interconnections. It should be noted in your report that a careful examination of annual costs, including capital cost, product cost, operation and maintenance costs, property taxes and depreciation, be made prior to the selection of a solution. Product cost should include the costs involved in providing Safe Drinking Water Act quality water in the quantities proposed during the periods proposed. Capital cost comparisons by themselves can be misleading, since the present worth value of paying for quality product over the years, until the year 2030, usually is many times the initial project cost.

I would like the opportunity to review the draft report further and possibly make additional comment. Please consider an extension to the August 13th deadline.

Very truly yours,

James McInerney

James McInerney
President
Stamford Water Company

JM:mh

NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
THE HARTFORD ELECTRIC LIGHT COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

General Offices • Selden Street, Berlin, Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06101
(203) 666-6911

August 17, 1982

D00120

Division Engineer
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Reference: Letter, J. L. Ignazio to Housatonic River Basin Urban Study Participants, dated July 19, 1982 (NEDPL-BU).

Dear Sir:

Comments on Draft Feasibility Report July, 1982
Housatonic River Basin Urban Study

In late July, 1982, Northeast Utilities Service Company (NUSCO) became aware of the above-referenced report, and subsequently requested and received a copy. NUSCO understands that the purpose of this report is to evaluate the practicality of water supply alternatives in the Housatonic River Basin. NUSCO, on behalf of The Connecticut Light and Power Company (CL&P) submits the following comments for your consideration to ensure that purpose is met.

CL&P operates hydroelectric stations along the Housatonic River within the area of the study. The so-called Housatonic Project, licensed by the Federal Energy Regulatory Commission (FERC) (Project #2576) consists of four separate developments. They are Bulls Bridge and Rocky River Stations located in New Milford, Connecticut, Shepaug Station located in Southbury, Connecticut and Stevenson Station located in Monroe, Connecticut. The Bulls Bridge, Shepaug and Stevenson Stations are run-of-the-river hydro generating stations, whereas Rocky River Station is a pumped storage hydro station. Rocky River Station uses the Housatonic River as the lower reservoir and Candlewood Lake as the upper reservoir.

The Draft Feasibility Study notes that Rocky River Station utilizes Candlewood Lake, but should make explicit the fact that Candlewood Lake is a man-made lake, built by CL&P in the 1920s expressly as a pumped storage facility. Virtually all of the lake bottom and surrounding lands up the 440 foot contour are owned in fee by CL&P.

Additionally, because the Rocky River Station is a federally licensed project, CL&P is subject to requirements of the FERC license and FERC regulations. Many of these requirements specify the conditions under which project lands can be used. This provides the assurance that the recreational, environmental, and historical values of the hydro developments are maintained and that the project continues to be operated for the public benefit.

NUSCO believes that these facts should be included in the feasibility report as part of the Candlewood Lake discussion. For your convenience, we have attached a suggested rewrite of that section of the draft report.

NUSCO strongly agrees with the study's finding that compensation for the loss of electric generation at Rocky River Station due to the withdrawal of water from Candlewood Lake and other potential impacts must be carefully analyzed prior to considering Candlewood Lake as a source of drinking water. We feel of course, that we should be consulted as part of that assessment. NUSCO also notes that water from Candlewood Lake is utilized not only at the Rocky River Station but also at the Shepaug and Stevenson Stations located downstream. Therefore, with respect to the section of the report dealing with the Shepaug diversion, we would again point out that the possible impacts on the operation of the Shepaug Station and Stevenson Station should also be identified and assessed.

Because of the significance of the report vis-a-vis CL&P's ownership and hydroelectric interests in the area, NUSCO requests that it be kept informed of the status of the Housatonic River Basin Urban Study and, also be sent comments submitted by study participants. We would also request that copies of future reports and correspondence on this matter be forwarded to us.

Should you have any questions or require further information, please contact Mr. Barry Ilberman, Manager, Land Administration at (203) 666-6911, extension 64915.

Very truly yours,

NORTHEAST UTILITIES SERVICE COMPANY
As Agent for The Connecticut Light
and Power Company

W. G. Counsil

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Senior Vice President

J. P. Cagnetta

By: J. P. Cagnetta
Vice President
Nuclear and Environmental Engineering

Attachment

cc: Mr. Lawrence R. Anderson, Director
Office of Electric Power Regulation
Federal Energy Regulatory Commission
825 North Capitol NE
Washington, D.C. 02426

Mr. Charles Lord
Office of Electric Power Regulation
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Mr. James D. Hebson
Regional Engineer
Federal Energy Regulatory Commission
26 Federal Plaza
New York, New York 10278

P.O. Box 8801,
New Fairfield, Ct. 06810,
August 26, 1982.

U.S. Army Corps of Engineers,
New England Division,
424 Trapelo Road,
Waltham, Massachusetts 02254.

Re: Comments on Draft Report - Housatonic Basin Urban Study.

Gentlemen:

I submit herewith my comments on the subject study. I am a registered professional engineer in the States of Connecticut and New York and was formerly the Director of Water Pollution Control for the City of New York(1954-1965). In that position I was an Associate Member of the Interdepartmental Board for the Sanitary Protection of the New York City Water Supply. This latter responsibility required an intimate knowledge of the vast New York City water supply system.

For some ten years after retirement from New York City service I was associated with Camp, Dressser & McKee of Boston, Mass. as a consultant. I was also a consultant to Malcolm Pirnie Associates on a proposal, initiated by me, to transfer water from the Housatonic River via Candlewood Lake to the New York City Croton System. Malcolm Pirnie at that time was part of an engineering triumvirate along with Metcalf & Eddy and Hazen & Sawyer who were retained by the State of New York to study new sources of supply east of the Hudson.

I was a part time resident of New Milford, Conn. on Candlewood Lake since 1941 and after retirement from New York a full time resident from 1964 to 1968. Since then I have been resident in New Fairfield, Ct. and have been involved, one way or another, in sanitary engineering. I am presently a member of a committee of New Fairfield considering the diversion of Ball Pond Brook into Margerie Reservoir.

I have for many years, since the drought of the 60s, favored the use of Candlewood Lake as a reserve water supply for the City of Danbury. It was I, who in the 60s, suggested to the then Mayor of Danbury that he declare an emergency and seek help from the Federal Government in borrowing and installing pipes and pumping equipment to divert water from Lake Candlewood to Margerie Reservoir. This was done and helped the city to weather the crisis. The pipe lines and pumping equipment, however, contrary to the statement made in your study, were removed and returned to Romulus, N.Y. There is no existing connection in place between the Lake and Margerie Reservoir.

In general, the Report is realistic. There are, however, several questions which might have been addressed more fully. In the NEWS Water Study made by your organization it was reported that if Candlewood Lake was used as a reserve reservoir the Lake and the Housatonic could yield some 160 MGD of water. In the Malcolm Pirnie, M&E, Hazen & Sawyer study they estimated the yield at about 102 MGD. Neither of these studies gave any consideration to the constraints of Connecticut Law relating to the prohibition of using water containing treated sewage effluent. You have discussed this under "Planning Constraints" in paragraph 3 on page 15.

It seems to me that this policy which exists in only two states, Connecticut and Rhode Island, should have been more thoroughly discussed and an opinion rendered as to its justification. The NEWS Study, as I recall, did not address the policy at all.

The safe yield of the Danbury, Conn. system, as noted on page 29, does not include the existing Kenosia wells nor the Osborne St. wells. I might also note that you have endorsed the diversion of Ball Pond Brook into Margerie Reservoir but no comment was made on the sanitary quality of the supply. In my experience with the City of New York we would have required the sewering of an area such as this before considering it for water supply. Such a move is not economically feasible either for Danbury or New Fairfield and thus your endorsement of such a supply is questionable. I was the Project Consultant for Camp, Dresser & McKee on the New Fairfield Sewerage Study and am quite familiar with the problems and economics. The drainage area includes older areas of the town containing aging septic systems of dubious design and construction which will deteriorate further posing overflow problems into Ball Pond Brook. A portion of the commercial area with worse septic problems is also tributary to Ball Pond Brook upstream from the proposed location of the pumping station.

With respect to the flood problem I do not believe that the study accurately evaluated the damage caused by the floods of August and October of 1955 particularly in the Danbury, New Milford, New Fairfield and other neighboring areas of the Housatonic Valley. I made a study for New Fairfield which was submitted to the Federal Emergency Management Agency of the Federal Insurance Administration. One section of town, the Musket Ridge area, would be isolated in a 100-year frequency flood. Your study, on page 13, indicates that only one commercial building would be affected. The consultant who made the study indicates that this particular structure would only be affected by a 500-year flood.

The studies made for Danbury, for instance, did not accurately reflect the flood flows of the smaller tributaries of the Still River such as Padanarum Brook which overflowed in later years causing considerable damage to the North Street Shopping Center and other establishments nearby. In 1955 the Goldens Road Bridge was overtopped and if there was a recurrence of that magnitude a new bridge would be overtopped isolating an apartment community south of it.

In a paper entitled Northeastern Floods of 1955: Rainfall and Runoff" by Tate Dalrymple, A.M. ASCE, who was the Chief, Flood Section, Surface Water Branch, Water Resources Division, U.S. Geological Survey, data is presented which shows that the flood runoff from drainage areas under 10 square miles in area were in the order of 1000 cubic feet per second per square mile. Obviouly a recurrence of such an event would cause heavy damage along Padanarum Brook in Danbury and inundate the North Street Shopping Center. Other similar areas in Danbury, Bethel, New Fairfield and New Milford would suffer comparable damage.

The section on Flood Control does not appear realistic to me. It needs further refinement.

Respectfully submitted,

William A. O'Leary

William A. O'Leary, P.E.

CC: Representative Martin Smith, Jr.
William Buckley, Sup't. Public Utilities, Danbury, Ct.

Stamford Water Company
103 Summer Street • P. O. Box 1196
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Tel. (203) 324-3163

August 27, 1982

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Re: Housatonic River Basin Urban Study
Public Review Draft Feasibility Report

Gentlemen:

Given the opportunity to make further comment I offer these observations regarding your design and analysis of the Shepaug Diversion Alternative. The pipeline need NOT be 38 miles long. By strengthening the interconnections between Stamford and Greenwich, the pipeline could terminate in the Stamford system, not at Trinity Reservoir (water flows from Mill to Trinity by gravity) but on the Mill Reservoir watershed in Ridgefield, Connecticut at the intersection of the Mill River and Route 35. This shortened version would be only 28 miles long and would benefit the same communities. The cost of such a project would be approximately $31 million.

Furthermore, if the source for this pipeline were Candlewood Lake instead of the Shepaug River, the pipeline would be shortened again by some 4 miles to 24 miles at an approximate capital cost of $27 million. Product cost in both cases would be zero and the incremental cost of providing Safe Drinking Water Act quality water would be incrementally minimal since all communities involved presently have or are constructing filtration plants.

Again, I remind you that capital cost comparisons by themselves can be deceiving, since the present value of paying for quality product over the years can vary widely with each project.

Very truly yours,

James McInerney
James McInerney
President
Stamford Water Company

JM:mh

CHARLES S. PUTNAM
120 VALLEY FORGE ROAD
WESTON, CONN. 06883

8/30/82

Mr. Joseph L. Ignazio
Chief - Planning Div
New England Div
US Corp of Engineers
424 Trapelo Rd
Waltham Mass. 02154

Dear Sir:

As a representative of Weston on the Southwestern (CT) Regional Planning Agency, I am writing with some questions regarding the 7/82 Report Entitled Housatonic River Basin - Urban Study.

① 99% of Westons 3000 homes have wells. There is no public water system. If Phase I on page 25 of the report is done (to "improve" BHC pumping at Westport and Wilton by 6.5 MGD) will there not be a lowering of the water table in Weston and a reduction in its ground water supply?

② On page 23 you mention the West Aspetuck Diversion. Nowhere in your Maps could I find where this diversion would be located. Can you provide a map or sketch locating this diversion.

③ Approx 65 of Westons 3000 homes are located along the East Branch of the Saugatuck ~~River~~. If you execute the BHC interconnection outlined on page 24, it seems pretty well assured that by diverting 12.0 MGD from BHC system to Stamford, the flow in this river would be

over

greatly reduced, thereby reducing property values and recreation along this river. Do you agree? Also, is there a sketch or map which indicates where the route would be of the Phase III connection between Hemlocks reservoir and the existing pipe line - which is described on page 25.

Would appreciate your response to these questions.

Sincerely yours,

Charles D. Putnam

cc 1st Selectman

COMMENT RESPONSES

The following are responses to specific questions and issues raised in the preceding letters:

- The wet months terminology used on page 22 of the Main Report refers to river flows not rainfall. For example, on the Shepaug River, as can be seen on page B-39 of the Plan Formulation Appendix, the average flow for December through May is 4 to 5 times that of the remaining months and thus referred to as the wet months.

- A maximum diversion of eleven mgd was assumed for the Shepaug River, because plans were developed to meet the long term needs for water supply which in this case were eleven mgd.

- The table on page 31, alternatives for Greenwich, does not have a plan for a Bridgeport Hydraulic Company (BHC) interconnection. The reason for this is that the BHC can supply water to Stamford which will cause them to have excess water available for sale to Greenwich.

- It is not within the scope of this study to determine the economic feasibility of removing sewage discharges from the Shepaug River to allow it to conform to State requirements as a supply source.

- This study was only authorized through a Stage 2 level. The Stage 2 analysis involves a screening process to determine which sources are feasible for development for water supply purposes. The process is not designed to provide a level of detail adequate to determine the best source for development only those that can feasibly be implemented.

- The year 1980 was chosen as the base year for the study due to the fact that detailed water use information was available. Projection of future demands are based on the 1980 data and to change the base year now would disrupt these projections.

- The Cannondale aquifer in Wilton, Connecticut was not studied in detail as an alternative because it is in the process of being developed for water supply by Bridgeport Hydraulic Company.

- If phase I of the Bridgeport Hydrualic Company interconnection plan (increase the capacity of the Wilton pump station to 6.5 mgd from the existing capacity of 5 mgd) is implemented, it will not effect the groundwater in the area. The additional water will be supplied from within their system not from groundwater. As a result, the water table in the Weston area will not be lowered.